2007
Tongue River Hydrology Report
Tongue River Information Program

Prepared for:

Montana Board of Oil & Gas Conservation

Montana Department of Natural Resources and Conservation

by:

Hydro Solutions Inc

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EXECUTIVE SUMMARY

The Tongue River valley of Wyoming and Montana has over 60,000 acres of irrigated land which have supported cattle ranching and farming operations for more than 100 years. The Tongue River also runs through the coal-rich Powder River geologic basin which has experienced growth in coal bed natural gas development since 1999, along with surface coal mining since the early 1970's. The Tongue River Information Project (TRIP) has been funded by the Montana Board of Oil and Gas Conservation in 2006-2007 in response to concerns by irrigators, environmental regulators and policy makers that the discharge of produced water from coal bed natural gas (CBNG) production in the upper Tongue River basin could be affecting the water quality of the river and, in turn, soil properties and crop production. TRIP includes an agronomic and soils monitoring program called the Agronomic Monitoring and Protection Program (AMPP), and a hydrologic component, which is summarized in this Tongue River Hydrology Report. All TRIP reports may be accessed on-line at: http://www.tongueriverampp.com/default.aspx.

The findings of the hydrology evaluation begin with the understanding that water supply available to the Tongue River is directly related to the amount of precipitation falling in the upper basin. Further, it is well-documented that water quality indicators, in particular Specific Conductance (SC- a measure of total dissolved solids) and sodium adsorption ratio (SAR), are inversely related to flow; that is, the river has higher SC and SAR at lower flows, and vice versa (USGS, 2007). The average annual flows at the US Geological Survey State Line gauging station for Water Years 2000 through 2006 have all been less than the median flow based on 46 years of measurements (448 cfs). Four of the past six Water Years have been the lowest average flows of record.

Comparisons of SC and SAR data at comparable stream flows for periods before and after the onset of CBNG development do not indicate increasing trends at any USGS monitoring station on the Tongue River. An increase of salinity and sodium in the downstream direction is a common occurrence for the Tongue River and other western streams, due to a combination of natural and human-caused factors. The largest increases on the Tongue River occur between the USGS stations at Monarch, Wyoming and the State Line, and between Brandenberg and Miles City, based on data from Water Years 2004 and 2005. The most significant influences on water quality in these stream reaches are changes in surface geology and the degree of irrigation. CBNG discharges contribute salts and sodium in the upper reach, but have no role in the lower reach since the lowermost CBNG discharge is about 1 mile below the Tongue River Dam.

The Tongue River basin is home to approximately 25,000 people, 88% of whom live in and around Sheridan, Wyoming. There are at least 60,000 irrigated acres in the basin, 73% of which are in Wyoming. Water rights filing information demonstrates that claims for water from the basin are far in excess of its historic delivery capability. Just over 6,000 private water wells are drilled in the basin, 64% of which are in Montana, and most of which are for agricultural purposes. Through 2006, approximately 3,000 CBNG wells were installed in the basin, 73% of which are in Wyoming. The quantity of CBNG-

produced water within the Tongue River basin averaged about 3.1 gpm per well during 2006 in both states, for an equivalent total of 19.4 cubic feet per second (cfs). Approximately three-fourths of this total was discharged to off-channel facilities, beneficially used, or treated prior to discharge, with the remainder discharged to the river untreated via MPDES or WYPDES permits.

There are seven permits for discharge of CBNG-produced water to the Tongue River, three of which are in Montana and four in Wyoming, with a total of 36 outfalls. These permits are authorized for discharge of from 1,640 to 2,630 gpm (3.6 – 5.9 cfs) of untreated CBNG water, and 4,438 gpm (9.9 cfs) of treated CBNG water. Actual CBNG discharges have been significantly less than the permitted discharges. The discharge rates and/or water quality authorized by permits are seasonally adjustable in order to meet irrigation water standards set by the State of Montana.

Agricultural non-point sources of contaminant discharge to the Tongue River have not been quantified. In 2002, the NRCS identified 20 visible irrigation return flows exclusive of those in Rosebud County. The portion of the Tongue River immediately downstream from the TY diversion dam to the mouth is listed as impaired on the MDEQ's current (2004) 303(d) list, and on the Draft 2006 list. The impairment is primarily due to a combination of the diversion of relatively good quality water from the Tongue River at the T&Y diversion dam, and the inflow of poorer- quality water from irrigation return flows, groundwater and tributaries.

This review demonstrates that although the Tongue River basin drains a mostly rural setting, it is a hard-working watershed, that has to date successfully supported both a long-standing agricultural economy and a rapidly-developing energy industry. Based on the combination of lengthy drought conditions, energy development and concerns over irrigation water supplies, continued monitoring of the river's flow and quality, and an improved accounting of basin-wide point and non-point sources of contaminants is warranted.

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Foreword

The Tongue River Hydrology Report is a companion report to the Agricultural Protection and Monitoring Program (AMPP) Report, produced under the auspices of the Tongue River Information Program (TRIP). This program was funded in 2006-2007 by the Montana Board of Oil and Gas Conservation (MBOGC), a division of the Montana Department of Natural Resources and Conservation. The AMPP program was originally launched in 2003 by Fidelity Exploration and Production Company, a subsidiary of Montana Dakota Utilities, in response to concerns by Tongue River irrigators over whether crop yields soils or water quality were being affected by discharges from the coal bed methane industry. The scientific methodology and implementation of the AMPP was developed by soil scientists, William Schafer and Kevin Harvey of Bozeman, Montana, and agronomist Neal Fehringer of Billings, Montana. These scientists are the principal authors of the companion 2007 AMPP report.

Through its Administrator, Tom Richmond, the MBOGC specified that the TRIP project include a scientific summary of the available hydrology and water quality information on the Tongue River, to place the AMPP findings in context. This report provides that summary. The 2006-2007 TRIP contract was administered by HydroSolutions Inc, a Billings, Montana based environmental science and engineering firm. The principal author of this report was Tom Osborne. Review and comments on the report were provided by Joel Adams of HydroSolutions, and William Schafer of Schafer Limited. Biographical sketches of the authors and reviewers may be found on the web site for the Montana Board of Oil and Gas Conservation: http://www.bogc.dnrc.mt.gov The interpretations provided herein are solely those of the authors.

2007 Tongue River Hydrology Report

The Tongue River Information Program (TRIP)

The Tongue River is a principal tributary of the Yellowstone River, with its headwaters in the Bighorn Mountains of northern Wyoming, and its confluence with the Yellowstone River in southeastern Montana. The Tongue River valley, which is developed extensively for irrigated agricultural production, flows through the coal-rich Powder River geologic basin. Large scale coal strip mining in the valley has been on-going since the early 1970's and coal bed natural gas (CBNG) development since 1999. The Tongue River Information Program (TRIP) is an outgrowth of the Agronomic Monitoring and Protection Program (AMPP) which preceded it from 2003 to 2006. The AMPP program which was originally privately funded, was developed in response to concerns by Tongue River irrigators that the discharge of produced water from CBNG production in the upper Tongue River basin could be affecting the water quality of the river and, in turn, crop production.

The Montana Board of Oil and Gas Conservation (MBOGC) sponsored this program in 2006-2007 due to its significance to the energy production activities under its jurisdiction, along with the need to protect water resources of the State of Montana. The project includes scientific evaluations in the areas of agronomy, soil science, hydrology and water quality; and the public information and education related to project results. This report is a summary of the hydrology of the Tongue River watershed in Montana and Wyoming. It is a companion report to the AMPP report which presents the results of the crops and soils monitoring at the study fields in the Tongue River valley. Project reports and information for previous years may be found at: http://www.tongueriverampp.com/default.aspx. The current reports may be found on the web site for the Montana Board of Oil and Gas Conservation: http://www.bogc.dnrc.mt.gov.

Tongue River Hydrology and Water Quality Trends

The agronomic and soils studies developed by the AMPP portion of TRIP are designed to detect changes in soil salinity, sodium content and crop yields related to changes in irrigation water quality from the Tongue River. The hydrology portion of TRIP is a focused effort to assemble existing sources of flow, salinity and sodicity data on the Tongue River, and to evaluate the temporal and spatial trends along the Tongue River from Wyoming through Montana. This assessment integrates existing sources of stream flow data and of point sources and non-point sources of salinity loading to the Tongue River.

The specific tasks for the Hydrology Report include the following:

1. Obtain stream flow and water quality monitoring results for all U.S. Geological Survey stations and any other publicly-available monitoring on the Tongue River and its tributaries in Wyoming and Montana;

2. Obtain information from state agencies and irrigation companies regarding rates, volumes and quality of discharges into the Tongue River basin and withdrawals from the basin for industrial and agricultural uses during the 2006 Water Year (October 1, 2005 – September 30, 2006) including the quantities of produced water from oil and gas operations in the Tongue River basin to the extent that they are available.

3. Analyze temporal and spatial trends in stream discharge and water quality throughout the Tongue River basin.

4. Prepare a scientifically valid synopsis of the current year's discharge, salinity and sodium characteristics along the river, and to place the current year's information in the context of the available historical record.

1.0 Trends in Tongue River Flow and Water Quality

1.1 The Tongue River Basin

The Tongue River watershed landscape encompasses approximately 5,399 square miles in the states of Wyoming and Montana (Figure 1). The headwaters originate in north-central Wyoming and flow generally to the northeast into southeastern Montana. Approximately 70 percent of the watershed (3,781 square miles) lies in Montana, while 30 percent (1,618 square miles) lies in Wyoming. Numerous tributaries join the Tongue River as it flows to the Yellowstone River (NRCS, 2002). Major tributaries include Goose Creek, Prairie Dog Creek, Hanging Woman Creek, Otter Creek and Pumpkin Creek. The Tongue River Dam and Reservoir are located approximately 10 miles downstream of the Wyoming-Montana state line. It has a storage capacity of 79,071 acre-feet.

Three trans-basin water diversions, originally built in the 1880's, transfer water from the North Fork and South Fork of Piney Creek into Jenks Creek, a tributary of Prairie Dog Creek for irrigation. The transfers amount to approximately 60 cfs over an average 153 day irrigation season per year (Entech, 2001). Piney Creek is a tributary of Clear Creek and eventually the Powder River.

1.2 Relation of Streamflow to Precipitation

In plains regions, with elevations from 3,000 to 6,000 feet above mean sea level, annual average precipitation ranges from 10 to 14 inches, and rainfall is a more dominant form of the precipitation (Lindner-Lunsford, et al., 1992). Average monthly precipitation is greatest from April through September, and maximum temperatures occur in July, while minimum values occur in January

(MDEQ, 2003). About 75% of the year's precipitation falls as rain during the April-September growing season. May and June are usually the wettest months of the year.

Streamflow is driven by precipitation, although the relationship is complex in reality.

Variations in the pattern and timing of precipitation over the basin, and lag time between snowfall and snowmelt are some of the complicating factors. A general correlation between the 2-year moving average of annual precipitation at the Decker 1E weather station and streamflow in the Tongue River at the State Line gauging station is displayed in Figure 2 (WRCC, 2007).

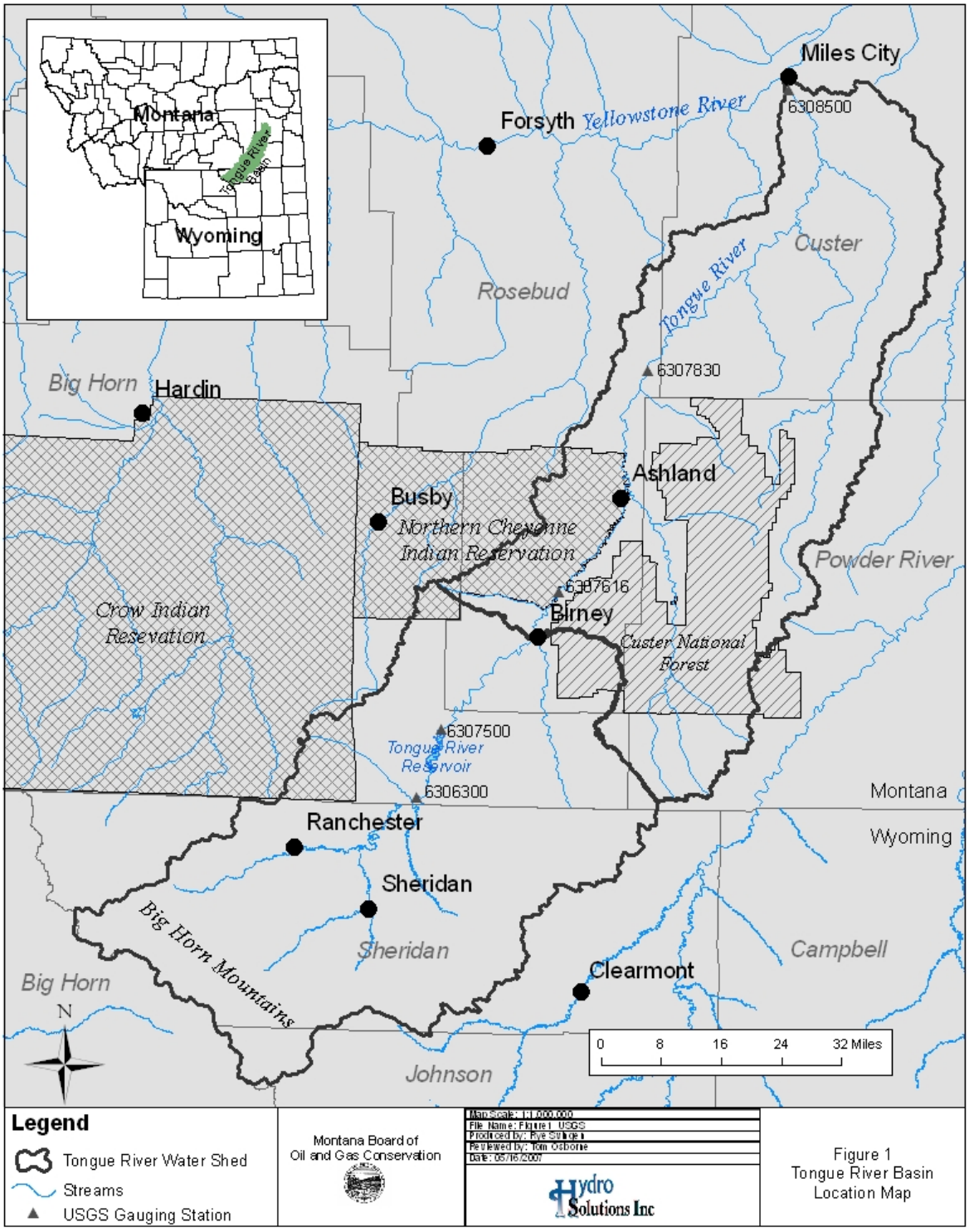

Figure 1 Tongue River Basin Location Map

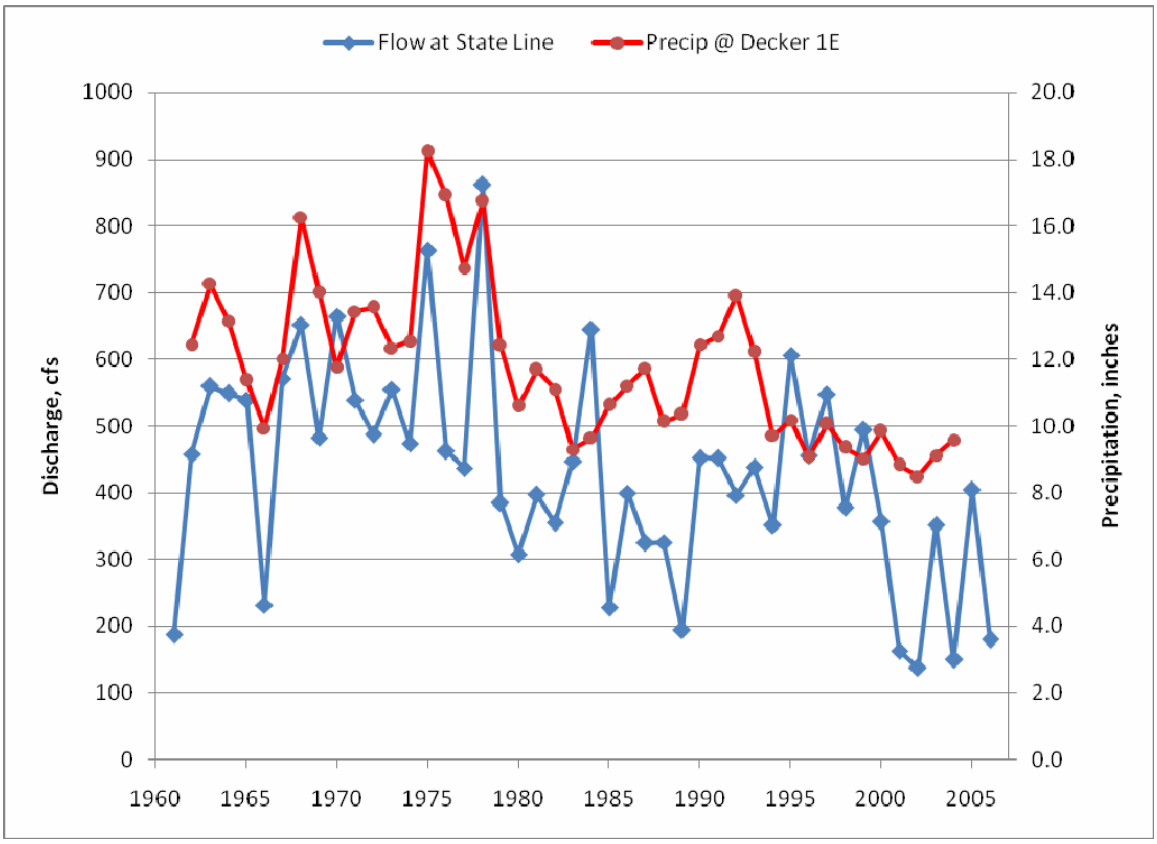

Figure 2 Average Annual Discharge of Tongue River at State Line Gauging Station versus 2-Year Moving Average Annual Precipitation at the Decker 1E Weather Station.

Correlation of precipitation with river discharge becomes less well defined at gauging stations lower in the basin because of the increase in the variability of the factors mentioned above, and an increasing number of human sources of diversions, discharges and impoundments throughout the basin, particularly the Tongue River Reservoir.

1.3 Long Term Flow Trends, Upper & Lower Basin

The average annual discharges for the Tongue River at Miles City and at the State Line gauging stations are depicted in Figures 3 and 4, respectively. The average annual discharge of the river at these stations for Water Years 1961 through 2006 is 297,000 and 312,000 acre-feet, respectively. Two general patterns emerge from the long-term discharge trends: year to year variation of 50 to 150 cubic feet per second (cfs), superimposed on longer-term swings of a decade or more that show variations of 400 to 600 cfs on an average annual basis. Long-term low flows were realized in the late 1930's, 1956, 1989 and 2002. Long term high flows were seen in 1945, 1971, 1984 and 1997. The 1970's also saw two abnormally large spikes of flow in 1975 and 1978. May 19-20, 1978 saw the largest flood of record, with 17,500 cfs measured at the State Line station and 10,800 cfs measured at the Tongue River Dam station.

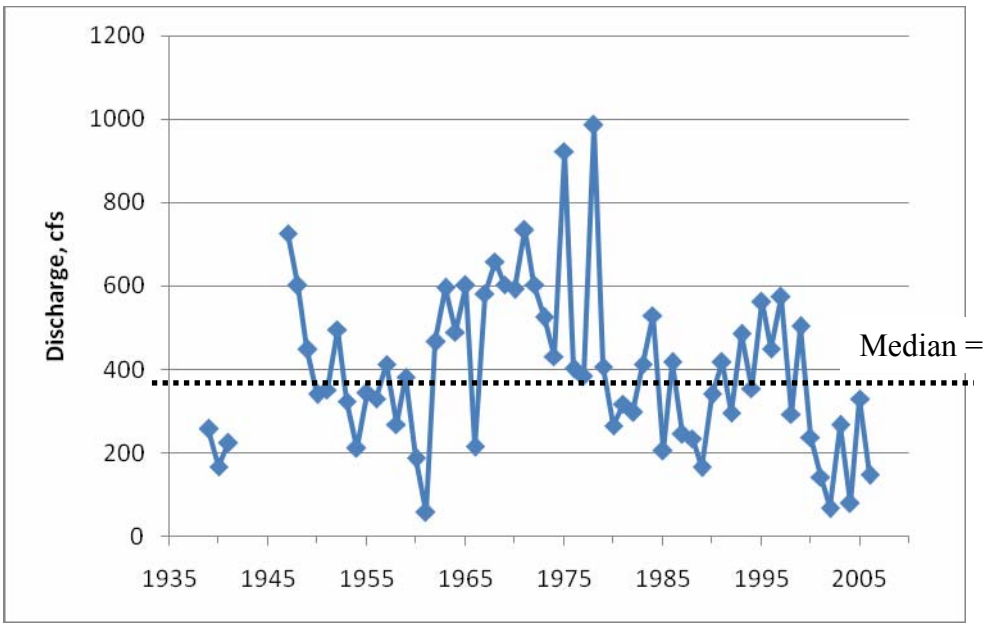

Figure 3 Annual Discharge of the Tongue River at Miles City, MT

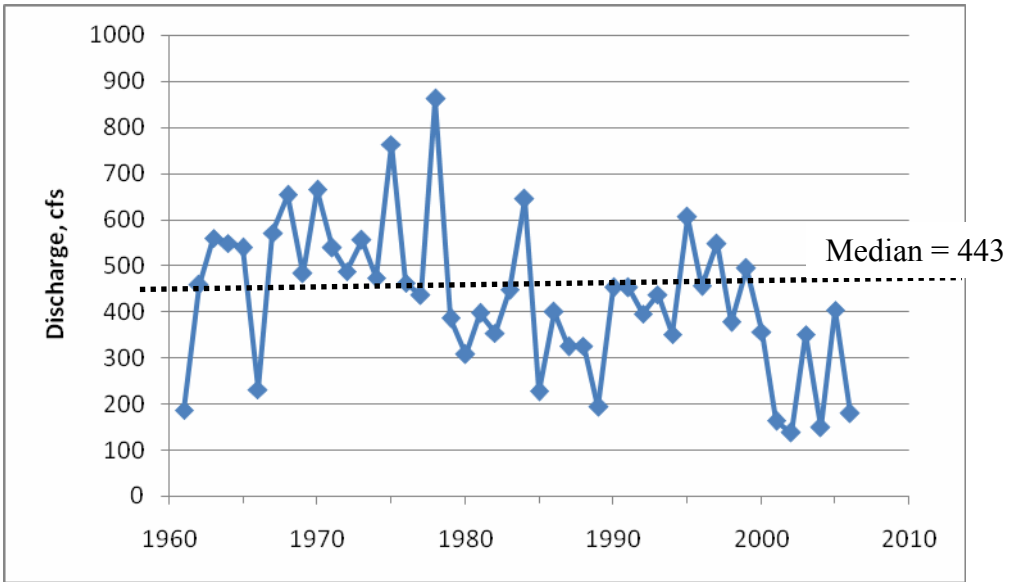

Figure 4 Annual Discharge of the Tongue River at the State Line

Since 1999, the average annual discharge of the Tongue River, both at the State Line and Miles City gauging stations has been less than the respective median flows,based on annual statistics for these two stations. Seven straight years of below normal flows is the longest such series in the monitoring records of both these stations. The 2006 Water Year was the fifth smallest discharge of record at Miles City, and the fourth smallest at the State Line station. Table 1 summarizes the rank order of annual discharges, from smallest up to the respective median flows over the periods of records for the two stations.

Table 1 Annual Average Low FLows for the Tongue River in Ascending Rank Order

Tongue River at State Line Median Annual Flow = 443cfs (1961-2006)		Tongue River at Miles City Median Annual Flow = 382 cfs (1939-1941, 1947-2006)	
Year by Rank	**Annual Discharge cfs**	**Year by Rank**	**Annual Discharge cfs**
2002	137.9	1961	57.2
2004	149.6	2002	67.9
2001	163	2004	79.5
2006	180	2001	143
1961	187.2	2006	147.1
1989	194.4	1989	165.5
1985	227.5	1940	166.5
1966	231.8	1960	187.6
1980	307.7	1985	204.7
1987	324.3	1954	212.2
1988	325.6	1966	215.2
1994	350.8	1941	224.8
2003	350.8	1988	235.1
1982	354.4	2000	237.7
2000	356.3	1987	244.8
1998	378	1939	257.7
1979	385.2	1980	266
1992	396.1	2003	266.2
1981	397.5	1958	268.5
1986	399.8	1998	293.5
2005	404	1992	296.1
1977	436.6	1982	297.2
1993	437.9	1981	318
1983	447.7	1953	324.3
		2005	329.7
		1956	330.2
		1990	340.6
		1950	340.7
		1955	343.2
		1951	351.8
		1994	354.6
		1959	382.2

A comparison of average annual discharge of the Tongue River at gauging stations between the State Line and Miles City indicates that in some years there are net increases in flow, while in others there are net decreases. Natural evaporation, riparian zone transpiration, and crop irrigation tend to deplete stream flow except in years where surface runoff and groundwater contributions are sufficient to offset these losses. A summary of average annual discharges at the

principal USGS gauging stations from 1961 to 2006 is provided in Table 2. Gray-shaded entries designate values which are less than that of the nearest upstream gauging station, indicating times that net decreases in average flow occurred between the stations.

Table 2 Trends in Down-River Discharge of the Tongue River, 1961 - 2006 Water Years

Water Year	State Line	TR Dam	Brandenberg	Miles City
	cfs	cfs	cfs	cfs
1961	187	154		57
1962	458	487		468
1963	559	582		596
1964	549	565		490
1965	539	542		602
1966	232	270		215
1967	571	567		582
1968	653	628		658
1969	483	512		604
1970	664	662		593
1971	540	554		735
1972	487	485		604
1973	556	565		526
1974	474	485	470	432
1975	764	782	886	924
1976	463	415	424	402
1977	437	437	417	384
1978	862	853	843	986
1979	385	377	418	407
1980	308	319	337	266
1981	398	374	363	318
1982	354	326	350	297
1983	448	446	451	413
1984	645	611	615	530
1985	228	250		205
1986	400	406		417
1987	324	296		245
1988	326	340		235
1989	194	206		166
1990	452	426		341
1991	452	422		417
1992	396	374		296

Water Year	State Line cfs	TR Dam cfs	Brandenberg cfs	Miles City cfs
1996	456	481		450
1997	548	572		574
1998	378	388		294
1999	495	468		503
2000	356	350		238
2001	163	174	182	143
2002	138	133	120	68
2003	351	309	324	266
2004	150	162	158	80
2005	404	366	347	330
2006	180	176	167	147
Years of Gain		***23***	***9***	***15***
Years of Loss		***23***	***8***	***31***
Average	***430***	***412***	***362***	***411***
Median	***443***	***424***	***363***	***410***

Note: Gray shading indicates stations having net stream flow loss with respect to nearest up-stream gauging station.

The data for Tongue River Dam station indicates that over the 46 years of record, 23 years show gains and 23 years show losses compared to the State Line station, with an average loss of 18 cfs. For the 17 years that the Brandenberg station has been in operation, nine years had gains in flow compared to Tongue River dam, while eight years had flow loss. The Miles City gauging station had 15 years of relative stream flow gains, with 31 years of losses when compared to the nearest up-stream gauging station (Tongue River Dam or Brandenberg). During the early 1980's and the early 2000's, seven straight years of stream flow losses occurred between Miles City gauge and the nearest upstream gauge.

1.4 Relation of Flow to Quality

Many authoritative sources have established that the water quality of the Tongue River, and that of many streams in the region, is directly related to the quantity of flow (USGS web site, 2007). The U.S. Geological Survey (USGS) maintains an internet web site specifically for the Tongue River, titled, "***Tongue River Surface-Water-Quality Monitoring Network"*** (see: http://tonguerivermonitoring.cr.usgs.gov/index.htm).
Their discussion of stream flow and water quality for 2004 and 2005 illustrates this concept:

"General hydrologic conditions are summarized because the volume of runoff is an important factor affecting water quality.

Streamflow in the Tongue River mainstream during March-October 2004 was below normal for the entire 8-month period, as illustrated in figure 2 for Tongue River at State Line. Most notably, peak flows during May and June 2004 were substantially smaller than the long-term average peak flows.

Below-normal peak flow and extended periods of low flow can affect water quality. The smaller amount of flow decreases the capacity of streams to dilute constituents contributed from tributaries, ground water, and point or non-point sources. Smaller flows also result in shallower water depths and slower velocities, both of which can cause increased water temperature and stimulate excessive growth of algae in stream channels. Finally, small peak flows generally correspond to less erosion and reduced transport of sediment.

The flows in 2005 may have affected various water-quality conditions by providing greater dilution of dissolved constituents, such as salts (major ions), and greater transport of suspended sediment and constituents adsorbed to sediment than in 2004. The large volume of runoff not only flushed the landscape and stream channels, but also replaced some of the water stored in Tongue River Reservoir with water having lower concentrations of dissolved constituents. Concentrations of dissolved salts in the reservoir presumably had increased during previous low-flow years owing to longer retention times and the effects of evaporative concentration." (USGS, 2007)

The relationship between salinity and stream flow can be made by comparing the specific conductance (SC) of the water with the rate of flow at each Tongue River gauging station when the USGS collects its periodic water quality samples. Figures 5 through 9 provide charts displaying this relationship for the main USGS gauging stations on the Tongue River, from upstream to downstream. Note that in each chart, solid diamond symbols represent the period of record prior to and through 1999, and open square symbols represent the period since and including 2000. The earliest CBNG production in the basin began in 1999 in both Wyoming and Montana. If there were trends of increasing SC and/or SAR since 2000, they would be evident on these graphs as a shift of those data points upward at any given rate of flow. Detailed statistical tests for potential differences were not performed.

Study of the charts reveals that there has not been a general increase in SC or SAR for comparable flows at any of the gauging stations. The graphs show that since 2000, the majority of the data points are shifted slightly to the left, which is indicative of the lower flows in this period. There is not a corresponding

trend to higher SC or SAR values, which would be indicated by an upward shift of the data points on these graphs.

In an overview of water quality in the Tongue River basin, Bobst (2007) conducted a statistical analysis and reported that when SC and SAR values for Water Year 2006 were normalized for flow at the State Ling gauging station, SAR had increased and SC had decreased. He stated that it appeared that this was due to decreased calcium and magnesium rather than increased sodium. Sulfate values also decreased according to Bobst, supporting the hypothesis that the decreased calcium and magnesium result from reduced overland and irrigation return flow inputs.

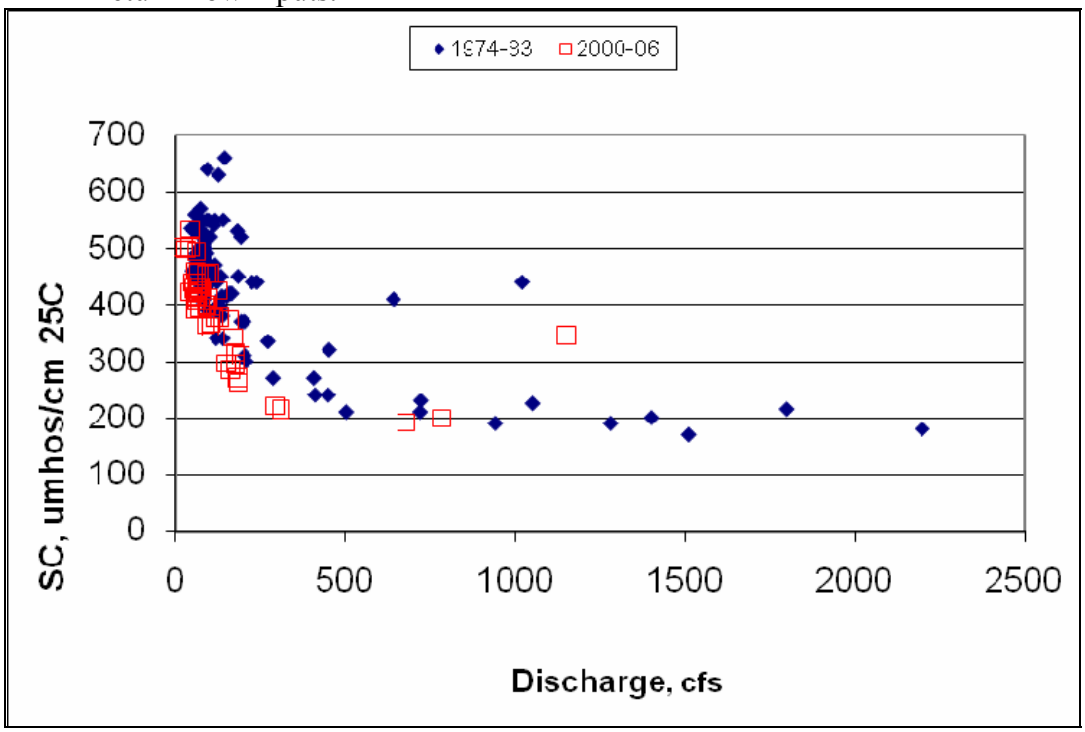

Figure 5 SC versus Discharge for the Tongue River at Monarch, WY.

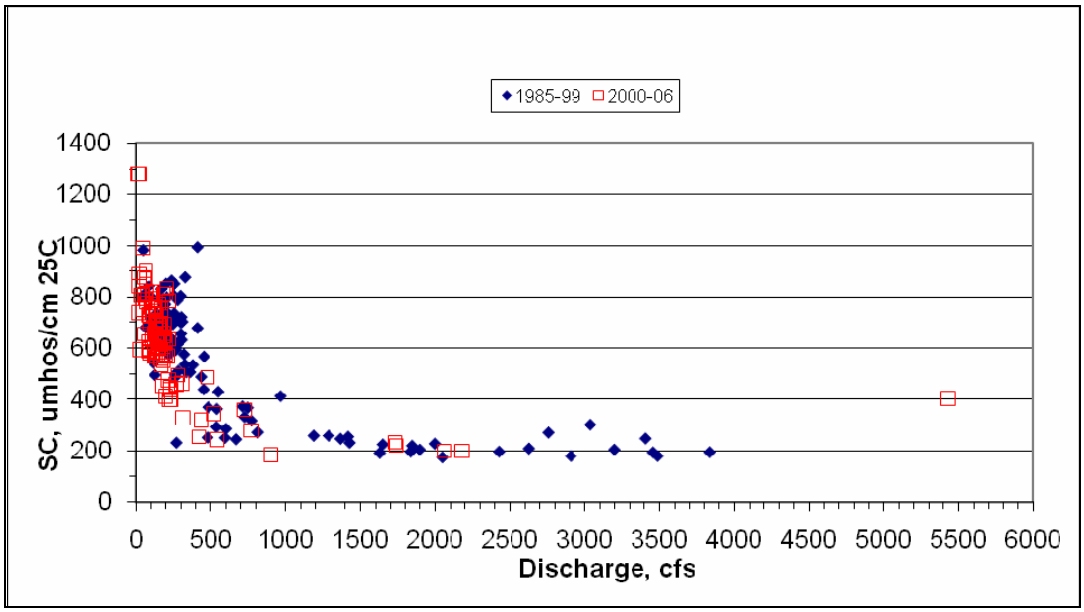

Figure 6 SC versus Discharge for the Tongue River at the State Line.

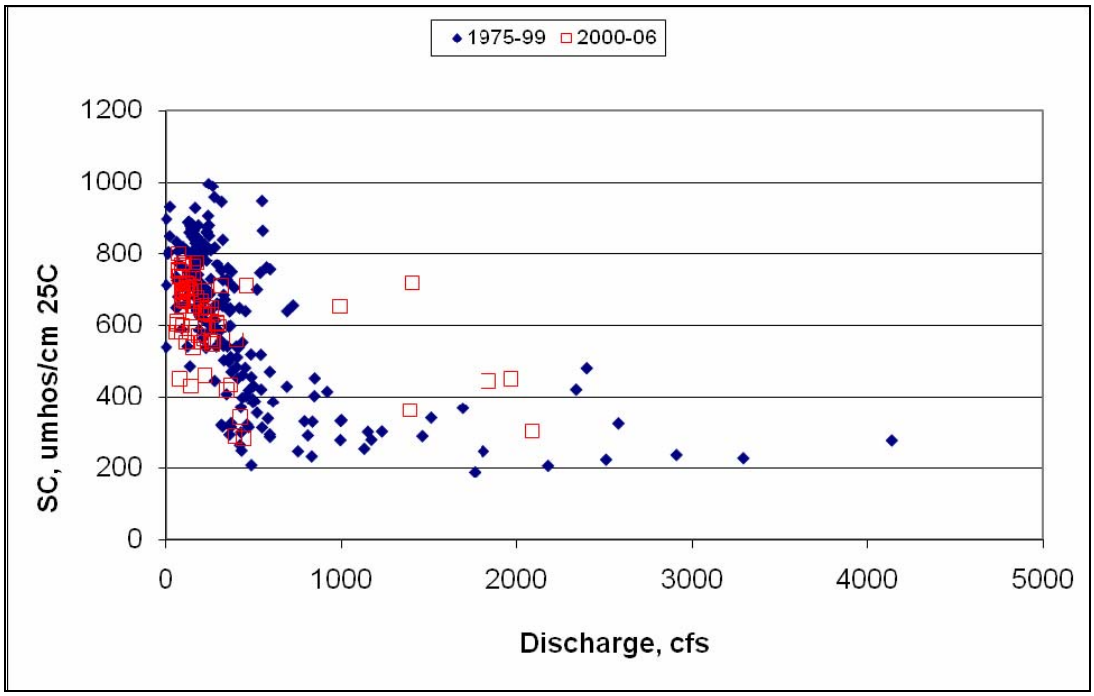

Figure 7 SC versus Discharge for the Tongue River at Tongue River Dam.

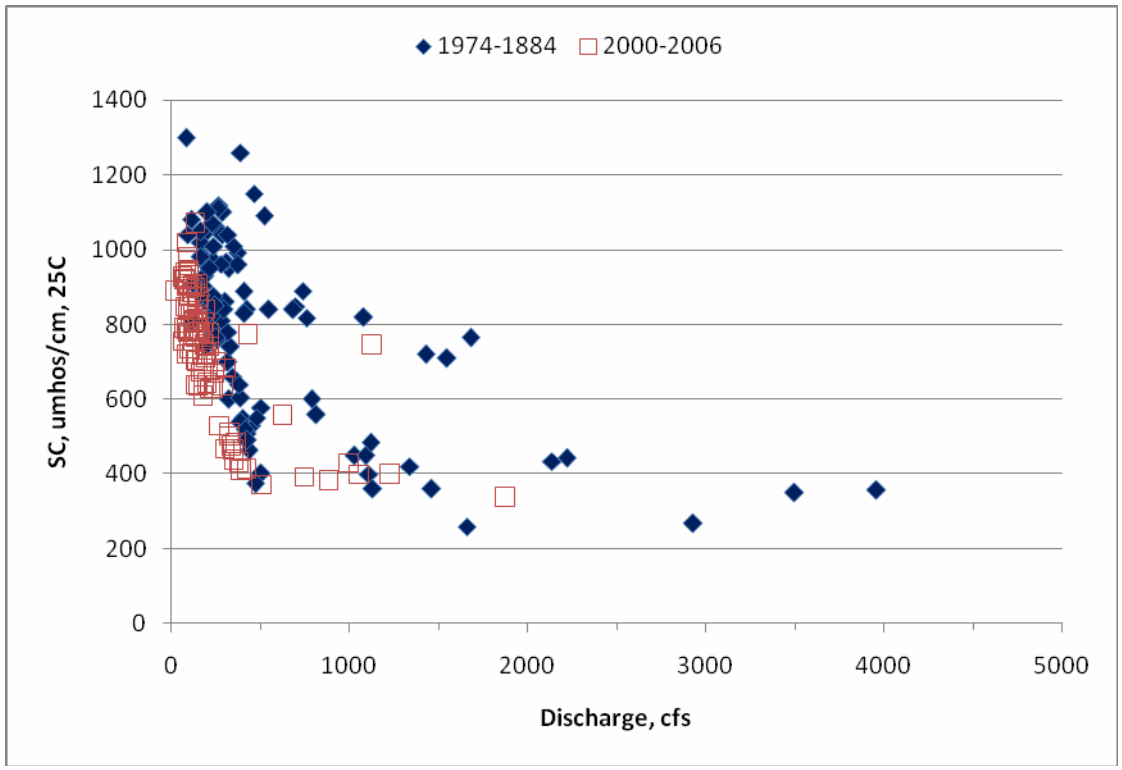

Figure 8 SC versus Discharge for the Tongue River at Brandenberg.

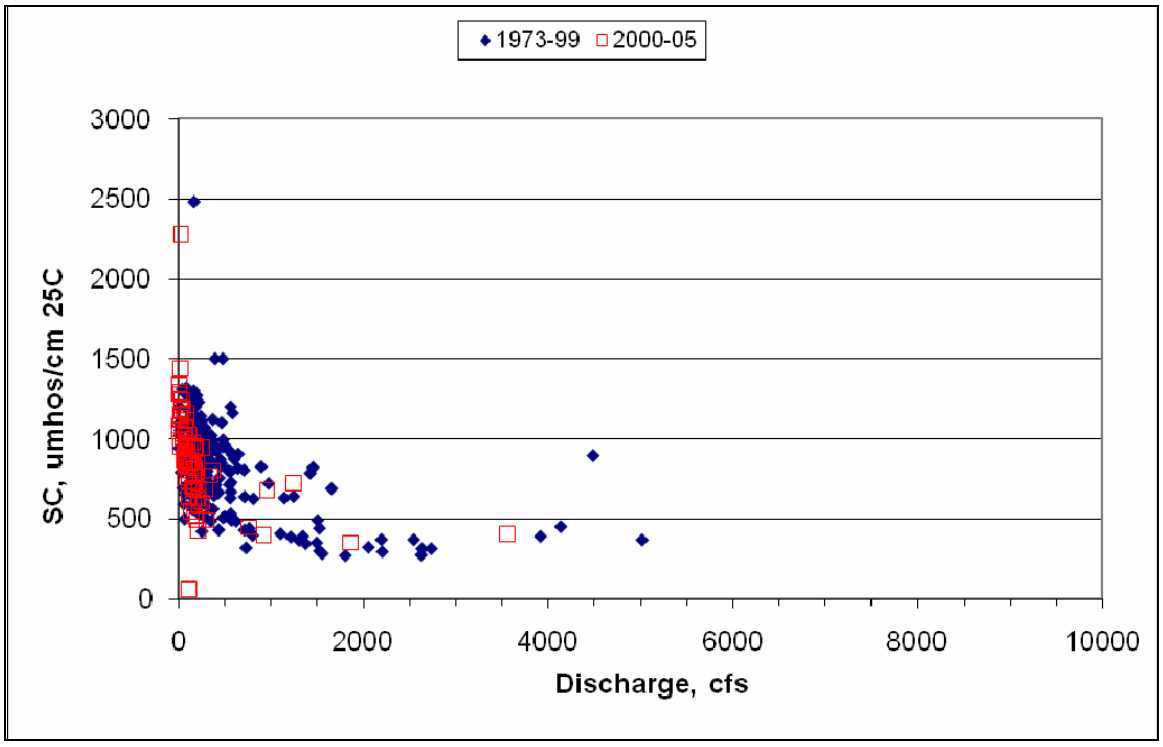

Figure 9 SC versus Discharge for the Tongue River at Miles City.

Similar streamflow-water quality relationship can be seen for sodium adsorption ratio (SAR) in the following charts, Figures 10 through 14.

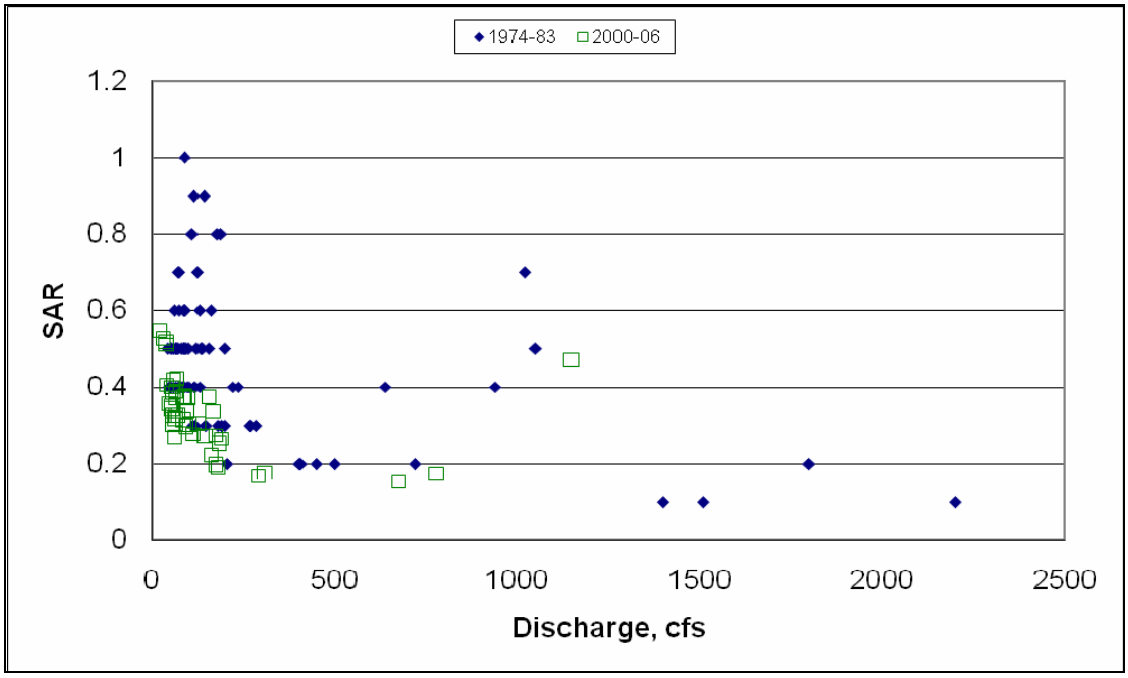

Figure 10 SAR versus Discharge for the Tongue River at Monarch, Wyoming.

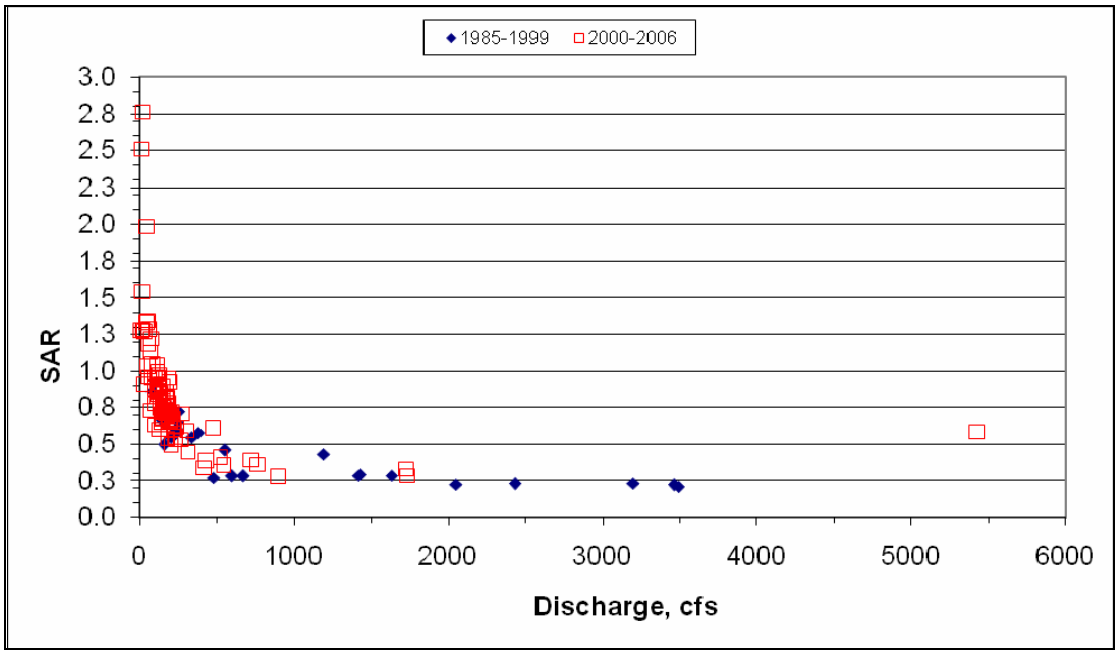

Figure 11 SAR versus Discharge for the Tongue River at the State Line.

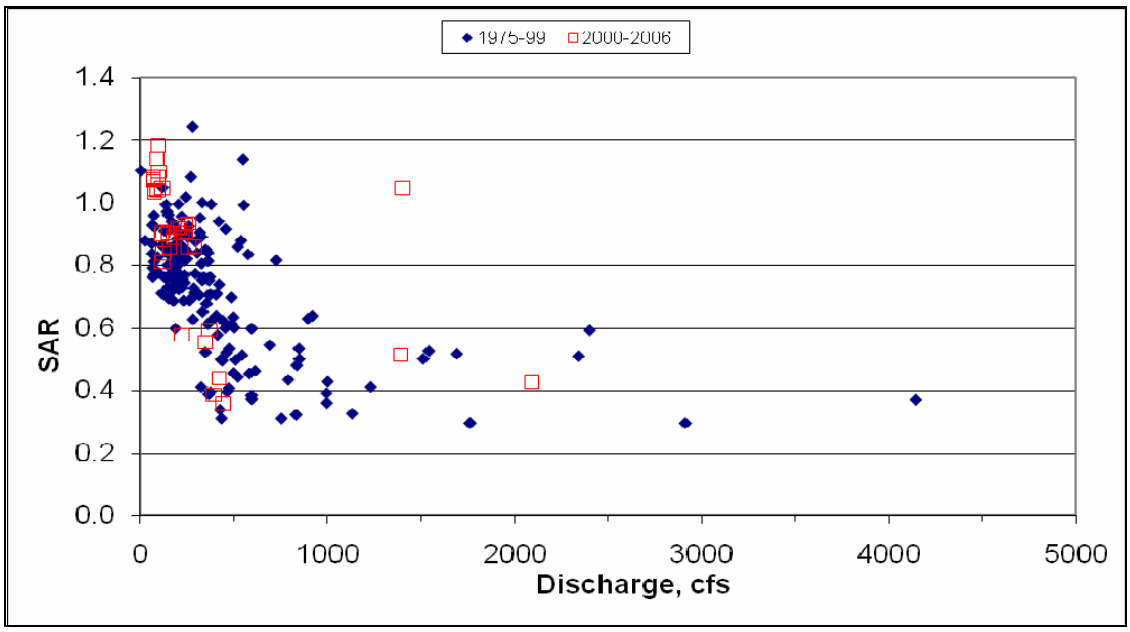

Figure 12 SAR versus Discharge for the Tongue River at Tongue River Dam.

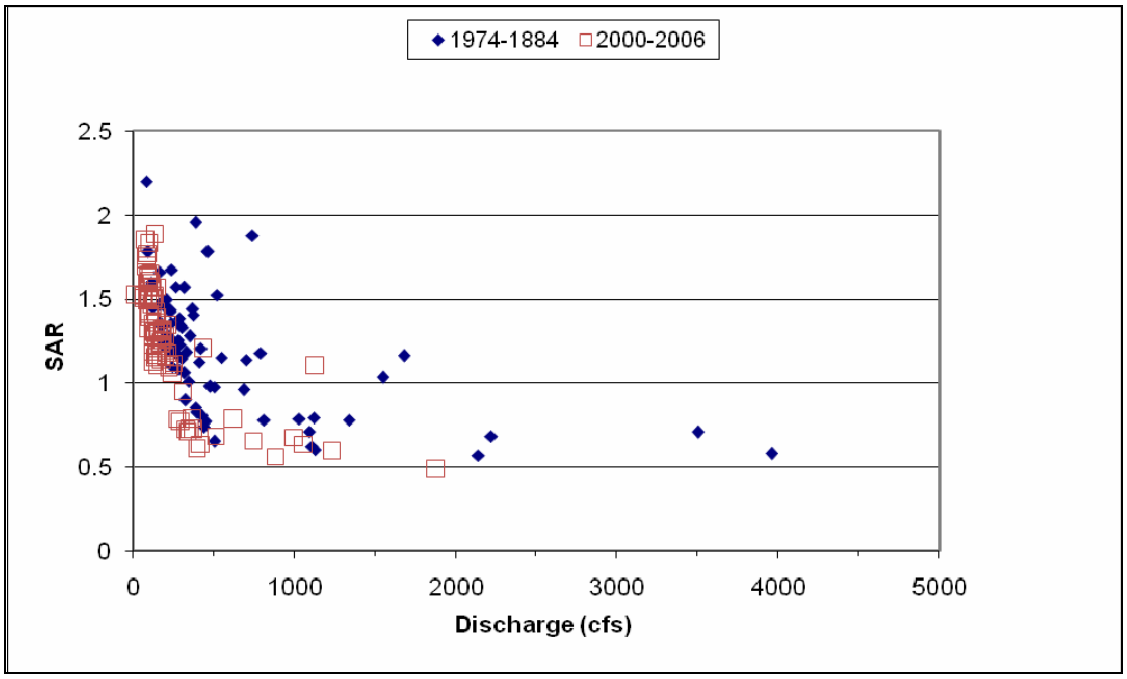

Figure 13 SAR versus Discharge for the Tongue River at Brandenberg.

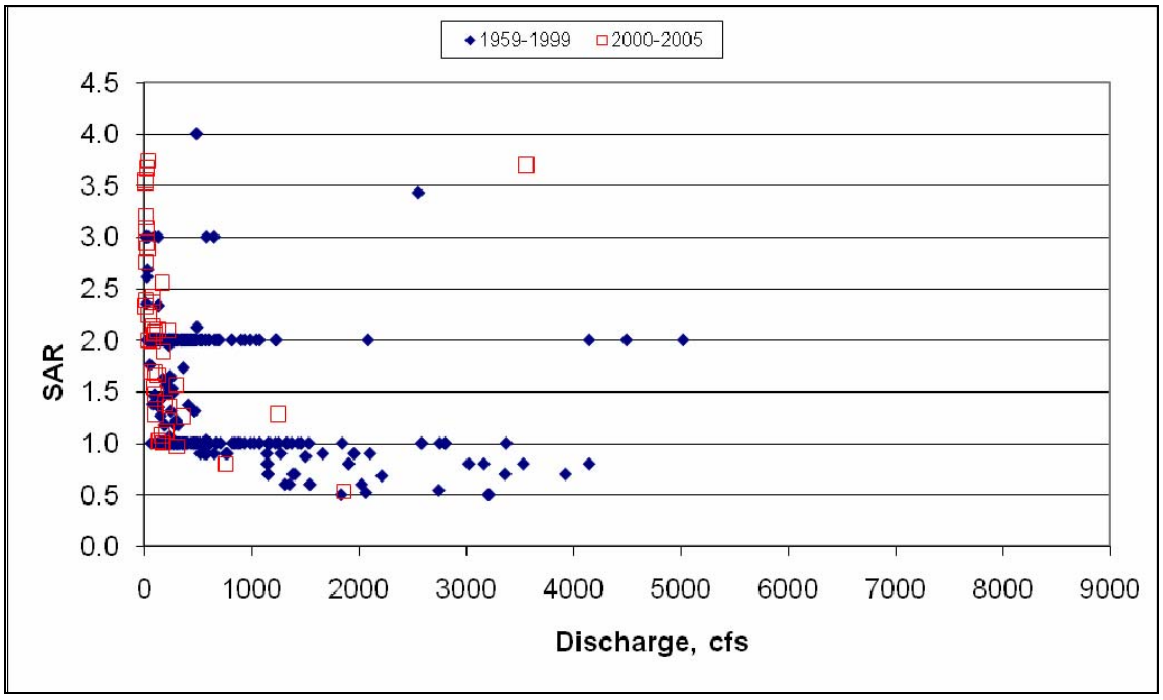

Figure 14 SAR versus Discharge for the Tongue River at Miles City.

1.5 Seasonal Trends in SC and SAR

The SC and SAR of the Tongue River have natural seasonal variations. The average monthly SC of the principal USGS gauging stations along the river is displayed in Figure 15.

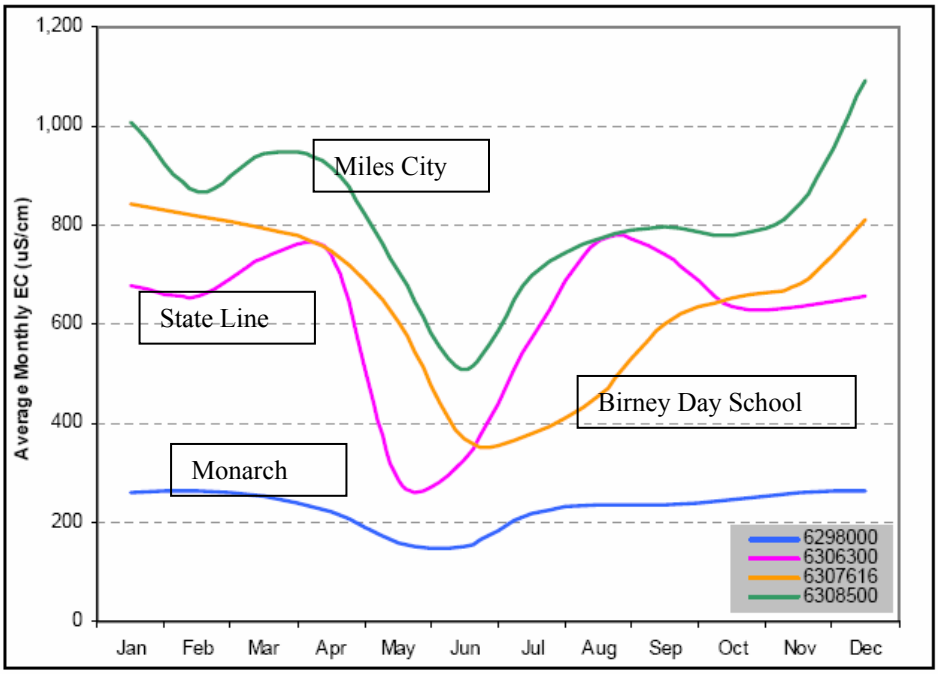

Figure 15 Average Monthly SC at four Tongue River stations, 1986-2001.
Source: MDEQ, 2003.

The highest SC values at the State Line station are seen in early spring when runoff from low-elevation areas contributes sediment and salts, and in late summer, when high temperatures and lower flows result in concentration of salts from evaporation and transpiration by riparian vegetation. The lowest SC values at all stations are associated with spring snow melt and runoff (USGS, 2007). The Tongue River reservoir stores some of the spring runoff and releases it later in the irrigation season, producing a delay in the downstream seasonal low SC compared to above the reservoir. The seasonal trend of SAR generally follows that of SC.

1.6 Down-River Trends in SC and SAR

The Tongue River picks up salinity and sodium in its downstream travel, a trend that is common to many western streams. Figures 16 and 17 illustrate the trends in average annual salinity and SAR for the Tongue River from Monarch, Wyoming to Miles City. Figure 17 includes data from the new station established just above the T&Y irrigation diversion dam.

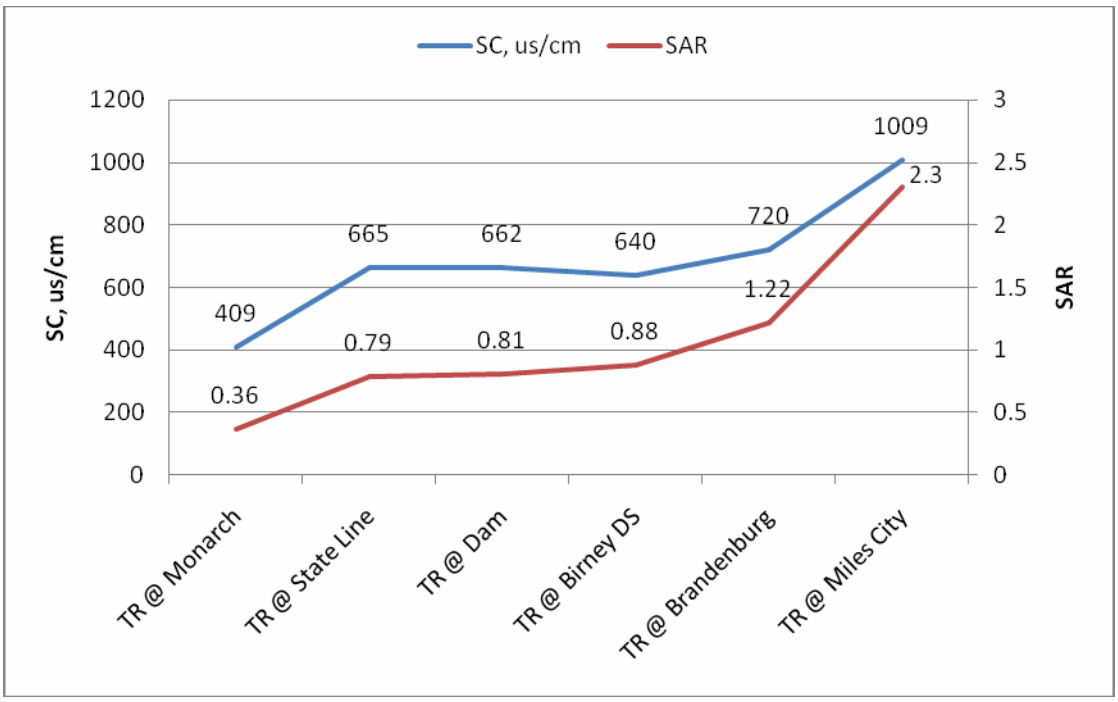

Figure 16 Down-River Trends in Average SC and SAR for the 2004 Water Year.
Source: Bobst, 2005

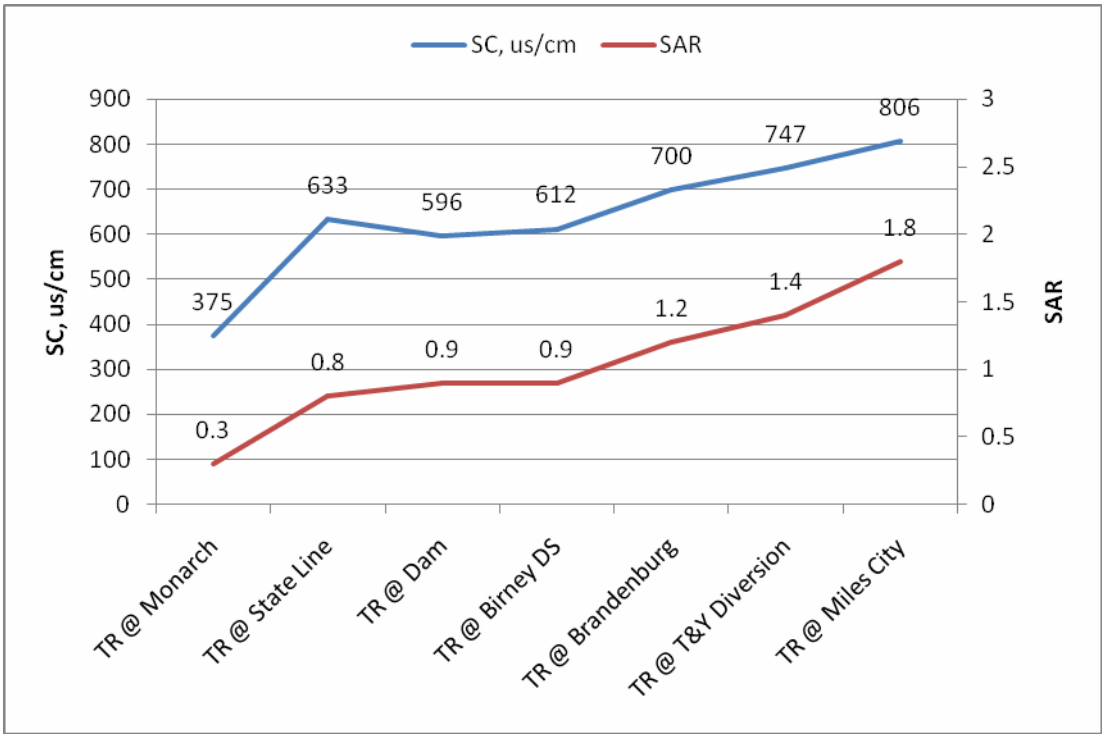

Figure 17 Down-River Trends in Average SC and SAR for the 2005 Water Year.
Source: Bobst, 2006.

The largest increases in SC and SAR occur between Monarch and State Line, and between Brandenburg and Miles City. Between Monarch and the State Line station, the Tongue River leaves the Bighorn Mountains and enters the plains region where natural salts from the Wasatch and Fort Union formations are more abundant. Salinity is contributed by Goose Creek which drains the City of Sheridan and the surrounding suburban area; and Prairie Dog Creek, which has naturally higher EC and SAR, but also drains an area of CBNG development along with irrigation diversions and return flows.

Between Brandenburg and Miles City, the surficial geology of the basin transitions from the Tongue River member of the Fort Union formation to the Lebo Shale and the Tullock members, which contain more natural salinity and sodium. Pumpkin Creek contributes salinity and sodium via surface and sub-surface flow, with most measurements exceeding the applicable Montana EC and SAR standards (Bobst, 2007). In addition, irrigation diversions decrease the dilution capacity of the river and irrigation return flows, which follow surface and subsurface pathways contain higher salinity and sodium concentrations than the river. During low flow periods, the water that is monitored at the Miles City station is more representative of irrigation return flows than of native Tongue River flow, because most of the water in the Tongue is diverted for irrigation during low flows (Bobst, 2006). It is notable that while there are general down-river increases in salinity and SAR, the Tongue River meets Montana irrigation season EC and SAR standards everywhere except at the Miles City gauging station.

The major tributary streams to the Tongue River usually have higher SC and SAR than the Tongue River at their respective confluences. Average annual SC and SAR values for the principal tributaries over Water Year 2005 are provided in Figure 18.

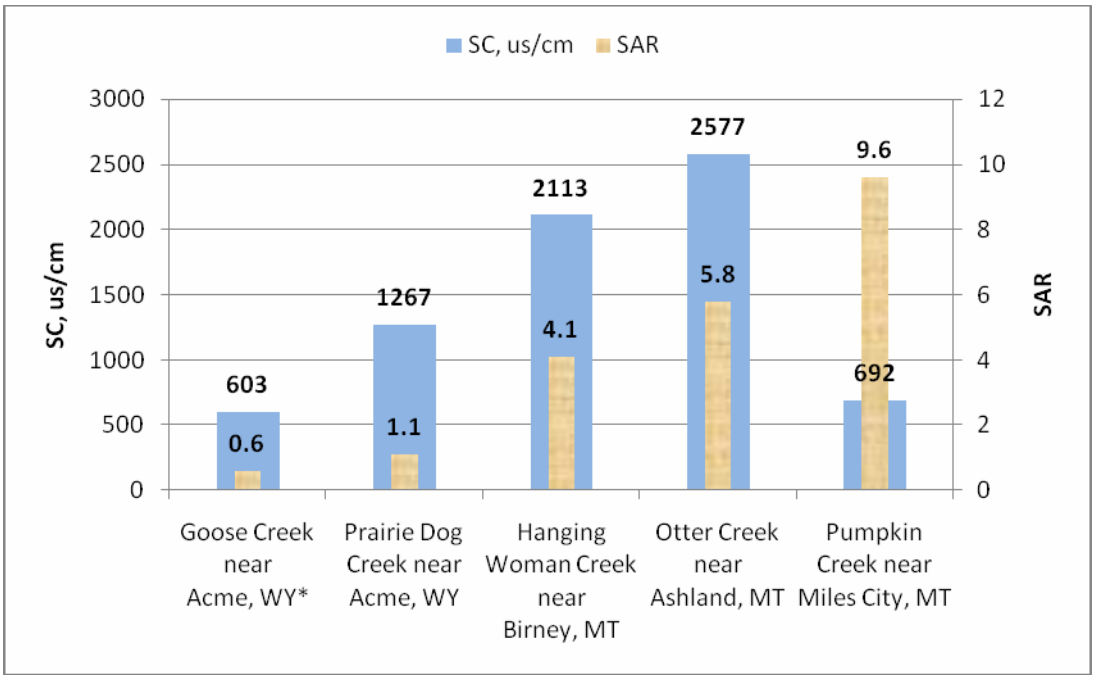

Figure 18 Average SC and SAR for Tongue River Tributaries, Water Year 2005.
Source: Bobst, 2006

In his report on surface water quality in the Tongue River basin, Bobst (2007) found that the water quality at tributary stations typically exceeded the MDEQ surface water standards for SC and SAR, and that elevated SC and SAR occurred even in watersheds where little or no CBNG development has occurred.

2.0 Trends in Water Use, Montana and Wyoming

2.1 Population

The total population for the watershed is not directly available but may be inferred from the 2000 U.S. Census data (MDEQ, 2003). A population analysis performed for the Tongue River TMDL Status Report (2003) found that approximately 25,000 people reside within the Tongue River watershed. The watershed urban and nonurban population totals by county are given in Table 3. The Wyoming portion of the Tongue River watershed is home to 22,460 people, which represents 88.3 percent of the total watershed population. The Montana portion of the watershed contains 2,974 persons, or 11.7 percent of the total.

Cities and towns account for 18,158 people (71.4 percent), while 7,275 people (28.6 percent) reside in nonurban areas (Table 3). Sheridan County, Wyoming has the largest total population in the watershed with 22,408 people (88.1 percent of the watershed total population), and it also has the largest urban population of 17,518 (68.9 percent of the entire urban population) within the watershed. The second largest total county population is found in Custer County, Montana, with 943 people (3.7 percent of the total watershed population). Most

of the Montana populations are found in Custer, Big Horn, and Rosebud counties, which represent 2,532 people, or roughly 85 percent of Montana's contribution to the total watershed population (11.9%). The largest urban center in the Montana portion of the watershed is the town of Ashland with a population of 385 people.

Table 3 Population Distribution within the Tongue River Basin

County	Total Watershed Population	Percent of Total Population	Nonurban Population	Percent Nonurban	Urban Population	Percent Urban
Sheridan, WY	22,408	88.1	4,890	19.2	17,518	68.9
Custer, MT	943	3.7	903	3.5	40	0.2
Big Horn, MT	841	3.3	806	3.2	35	0.1
Rosebud, MT	748	2.9	223	0.9	525	2.1
Powder River, MT	442	1.7	402	1.6	40	0.2
Johnson, WY	52	0.2	52	0.2	0	0.0
Total	25,433	100.0	7,275	28.6	18,158	71.4
Source: U.S. 2000 Census and GIS analysis. Adapted from MDEQ, 2003.						

2.2 Principal Water Uses

Agriculture accounts for 99 percent of all diverted surface water uses, and 61 percent of all groundwater uses in the entire Yellowstone River basin (Zelt, et al., 1999). Of the other one percent of surface water diversions, public water supplies account for 40 percent, thermoelectric power generation accounts for 33 percent and mining 9 percent. Of the other 39 percent of groundwater use, mining accounts for 65 percent, public water supplies account for 26 percent and other domestic water uses account for 11 percent.

Agricultural operations in the Tongue River watershed are heavily dependent on irrigation. According to the NRCS, there are about 36,000 irrigated acres in the Montana portion of the Tongue River basin. USGS records indicate that there are some 64,300 acres irrigated above the gage at the State Line near Decker for a total of 100,800 irrigated acres in the Tongue River basin (Shields and others, 2001; in NRCS, 2002). The MDEQ, utilizing GAP data in its TMDL Status Report (MDEQ, 2003) reported that the Montana portion of the Tongue River basin contained 16,785 irrigated acres, while the Wyoming portion of the basin contained 44,901 irrigated acres, for a total of 61,686 irrigated acres. The large discrepancy probably relates to differing information sources and methods, particularly partially served fields on intermittent and ephemeral tributary drainages. A map showing irrigated land in the Tongue River basin, as based on the GAP data, is provided on Figure 19. The irrigation information provided here

is that which is available from public records and does not represent actual irrigated area which varies from year to year with the availability of water.

The Tongue River Dam and Reservoir is located about 10 miles north of the Montana-Wyoming state line. The dam was planned and completed by the Montana Water Conservation Board in 1938. Reservoir storage area is about 3200 acres following an enlargement in 1999 that added 20,000 acre-feet to provide for the Northern Cheyenne Tribe's negotiated federal reserved water rights. Current storage capacity is 79,071 acre-feet. The project provides water for the irrigation of 15,000 acres of land between the dam and Miles City. Water use under contract includes 39,300 acre-feet for irrigation and 7,500 acre-feet dedicated for use by the Northern Cheyenne Tribe. Additional water is contracted for the fish hatchery near Miles City and the St. Labre Mission in Ashland. Total contracted water is 40,000 acre-feet. The Tongue River Water Users Association manages the dam.

In early 2002, DEQ and the Tongue River Water Users (TRWU) sent surveys to landowners in the watershed to obtain better information on irrigation practices. Some of the key findings of the surveys were summarized by the MDEQ in the TMDL Status Report (2003). Responding landowners indicated that close to 90 percent irrigate from the Tongue River or its tributaries. Most irrigate less than 50 acres of land but some irrigate as many as 9,400 acres. The average land area that is irrigated is 163 acres. Flood irrigation is the most common form of applying the water but sprinkler and spreader dikes are also employed. Almost 40 percent of the landowners that responded to the surveys reported that they have experienced crop yield problems due to existing water quality. Slightly more than half of the respondents reported having soil salinization problems.

The NRCS conducted a "rapid aerial assessment" of stream corridor reaches along the Montana portion of the Tongue River in 2001 (NRCS, 2001). Approximately 105 river miles were inventoried in Big Horn and Custer Counties. Rosebud County did not participate. The NRCS identified and mapped a total of 263 individual point and linear features. Irrigation pump sites (63 each) were by far the most prevalent type. Most of the pump sites appeared to serve full season irrigation systems.

The NRCS reported two direct diversions located on the Tongue River (NRCS, 2002). The Tongue River Diversion Dam is located on the Tongue River near the confluence of Pumpkin Creek and approximately 12 miles upstream of Miles City. It diverts a large portion of the Tongue River during the irrigation season (April to October/November) to the T/Y Ditch, which in turn supplies water to fields throughout the lower Tongue River watershed and irrigated areas in the Yellowstone River basin east of Miles City. Flows in the T/Y Ditch are approximately 200 cfs during the irrigation season when the ditch is full.

On the tributaries, water spreading systems are by far the more common method of water application compared to sprinkler or contour irrigation. In this

method, water is periodically diverted or ponded when available from the stream into a feeder canal or directly into a basin contained by earthen dikes. The NRCS report (2002) identified 20 surface irrigation return flows to the Tongue River.

2.3 Water Rights Information

Water rights information is another source of water appropriation and beneficial uses of water in the Tongue River watershed. Water rights information acquired by MDEQ (2003) from the Montana Department of Natural Resources and Conservation (DNRC) shows that currently there are 5,748,707 acre-feet of water per year in the Montana portion of the Tongue River watershed allocated to surface water rights, and 830,244 acre-feet of water per year allocated to groundwater rights. These amounts simply reflect the water right claims, which are far in excess of the total available water in the basin. The average annual amount of total water available from the river is approximately 320,000 acre-feet, based on the median annual flow at the State Line. As of early 2007, water rights in the Tongue River basin of Montana are in the assessment process by the DNRC (Kerbel, pers. communication). Water rights information indicates water is used for irrigation, municipal, stock watering, and domestic uses. As indicated in Table 4, most of the water appropriations (76 percent) are used for irrigation (MDEQ, 2003).

Table 4 Water Uses Designated by Water Rights in Montana Portion of Tongue River Basin

Water Purpose	Volume (acre-feet/year)	Percentage
Irrigation	4,981,187	75.7%
Municipal	557,562	8.5%
Stock watering	481,647	7.3%
Domestic	401,430	6.1%
Flood control	150,000	2.3%
Other	7,125	0.1%
Total	6,578,951	100%

Source: MDEQ, 2003

2.4 Water Well and Spring Information

Private water wells installed into shallow aquifers of the Tongue River basin are an important source of water for rural households, farms, ranches and livestock. Irrigation from shallow groundwater is typically limited to household lawns and gardens and not agricultural fields, due to relatively low well yields. Most private wells range in depth from several tens to several hundred feet. Wyoming State Engineer's records show that 93% of private water wells with reported total depths are 400 feet deep or less. Montana water well records (GWIC, 2007) indicate that 91% of private water wells with reported total depths

are 400 feet deep or less. Approximately 70% of private water wells in both states are 200 feet deep or less. The principal aquifers providing groundwater to wells include alluvium along stream valleys, along with coals and sandstones of the Fort Union and Wasatch formations.

The number of private water wells registered in public records in the Wyoming and Montana portions of the Tongue River basin are summarized in Table 5, and displayed on Figure 20. The "Other" category contains geotechnical borings, unused or unknown wells, public water supply wells, some oil and gas wells, monitoring and test wells, fire protection wells, and miscellaneous.

Table 5 Private Water Wells of Record in the Tongue River Basin

County	Industrial Wells	Domestic Wells	Agricultural Wells	Other	Totals
Big Horn, MT	21	81	280	743	**1125**
Rosebud, MT	1	177	408	138	**724**
Powder River, MT	1	230	1089	205	**1525**
Custer, MT	4	181	551	87	**823**
Sheridan, WY	2	1657	370	380	**2409**
Totals	**29**	**2326**	**2698**	**1553**	**6606**

Sources: Montana Ground Water Information Center (GWIC) and Wyoming State Engineer's Office

Coal bed natural gas (CBNG) produced from coal beds of the Fort Union formation in the Tongue River basin in both Wyoming and Montana entails pumping groundwater to reduce water pressure in the coal seams, facilitating release of natural gas. Coal beds are depressurized but are not dewatered. Pumping occurs from coal beds which also may serve as aquifers for private wells. Private water wells within several miles of active CBNG fields which are completed in gas-producing coal beds could experience drawdown of water levels, reduced yield, or gas migration into the well bore. However, most CBNG wells are deeper than private water wells. WOGCC (2007) indicate that 91% of CBNG wells in the Wyoming portion of the Tongue River basin are deeper than 400 feet. MBOGC (2007) records indicate that 78% of CBNG wells in the Montana portion of the basin are greater than 400 feet deep.

Gas producers in Montana are required to offer Water Source Mitigation Agreements to nearby well owners. Wyoming producers are not required to do so, but it is a common practice. Coal beds in the Powder River Basin are generally separated from other aquifers by shale units that act as confining beds or aquitards. Due to these confining shale units, significant water-level drawdown in response to CBM production is expected to be limited to the coal aquifers and is not expected to migrate vertically to impact overlying or underlying aquifers in most areas (Wheaton et al, 2006).

Springs are also important water sources for livestock and some domestic uses in the Tongue River basin. Original homesteads and ranches were sometimes located near historic springs. Springs typically issue from clinker beds, coal beds and sandstones near their contacts with underlying mudstone or shale units (Donato and Wheaton, 2004). Between 2001 and 2003, the Montana Bureau of Mines and Geology (MBMG) inventoried a total of 279 springs in the Montana portion of the Tongue River and Powder River basins (Donato and Wheaton, 2004). Of these, 164 were found to have a measurable discharge, which ranged from 0.01 gpm to 82 gpm. A total of 55 springs were found to have a discharge rate of 1 gpm or greater. The specific conductance of inventoried springs ranged from 123 to 8,540 µS/cm at 25C. No spring inventory is known to exist in the Wyoming portion of the Tongue River basin.

The MBMG spring inventory suggested that most springs are fed by local groundwater systems, which are unlikely to be hydraulically connected to coal bed aquifers that are targeted for CBNG production. In its recent Draft Supplemental Environmental Impact Statement (BLM, 2006), the BLM stated that the fact that a coal seam produces CBNG strongly suggests that it is isolated from a surface unit and therefore is unlikely to impact springs.

3.0 Oil and Gas Wells in the Tongue River Basin

The distribution of oil and gas wells in the Tongue River Basin is shown on Figure 21. One oil field (Ash Creek) and three gas fields (Liscom Creek, Pumpkin Creek and CX) lie within the Tongue River basin in Montana. Of these, only the CX field has been recently active (MBOGC, 2007). The CX field is a coal bed natural gas (CBNG) producing area in southern Big Horn County that is operated by Fidelity Exploration & Production Company. In 2005, the CX field produced 11,629,937 thousand cubic feet (MCF) of natural gas (MBOGC, 2007). Other companies have become active in exploration and initial development of CBNG in Montana in the past several years, including, Pinnacle Gas Resources, Powder River Gas, and Nance Petroleum Corporation. The history of CBNG well permitting and well completions from the MBOGC is provided in Figure 22. Nearly all of these permits and wells lie in the Tongue River basin. CBNG wells which tap federally owned minerals must be approved both the MBOGC and the U.S. Bureau of Land Management (BLM). The permits and wells shown in these maps and figures reflect approvals by MBOGC. Approvals by BLM for many of these wells are pending.

The number of CBNG wells and the average rate of water production per well for the CX field is shown in Figure 23. The historical trends in production of natural gas, water and well counts for CBNG production in the Montana portion of theTongue River basin is shown in Table 6.

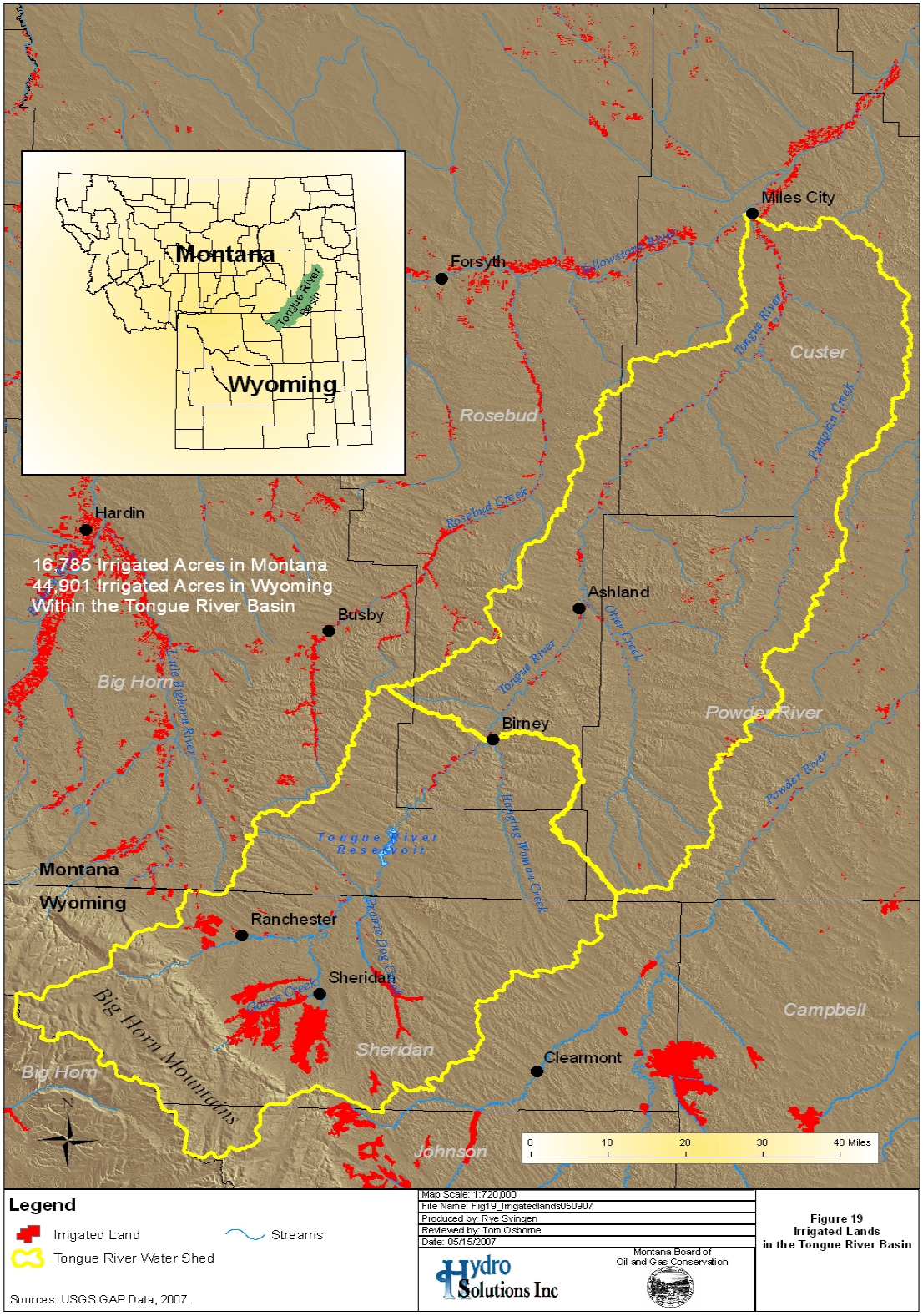

Figure 19 Irrigated Lands in the Tongue River Basin

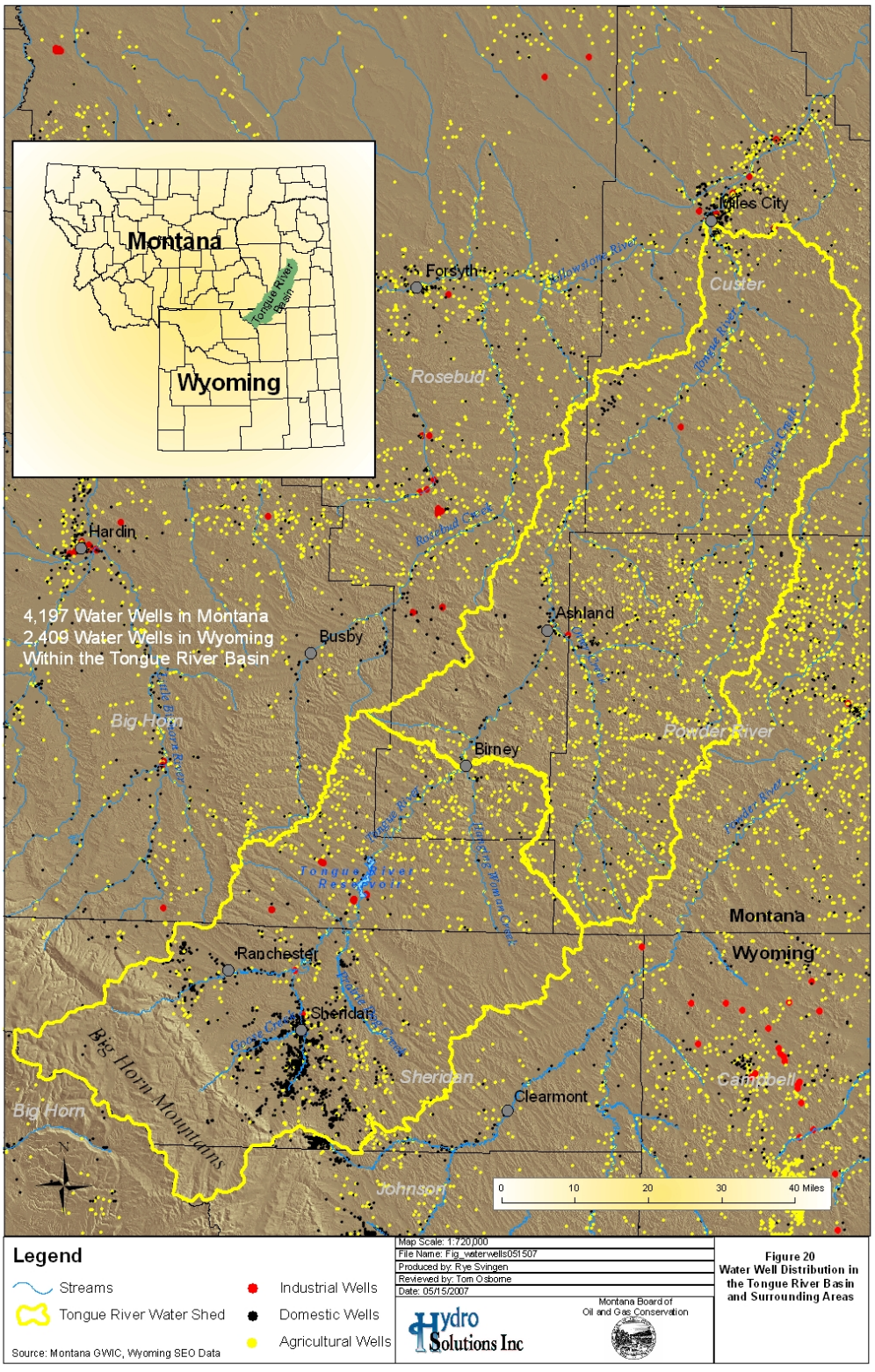

Figure 20 Water Wells Distribution in the Tongue River Basin and Surrounding Areas

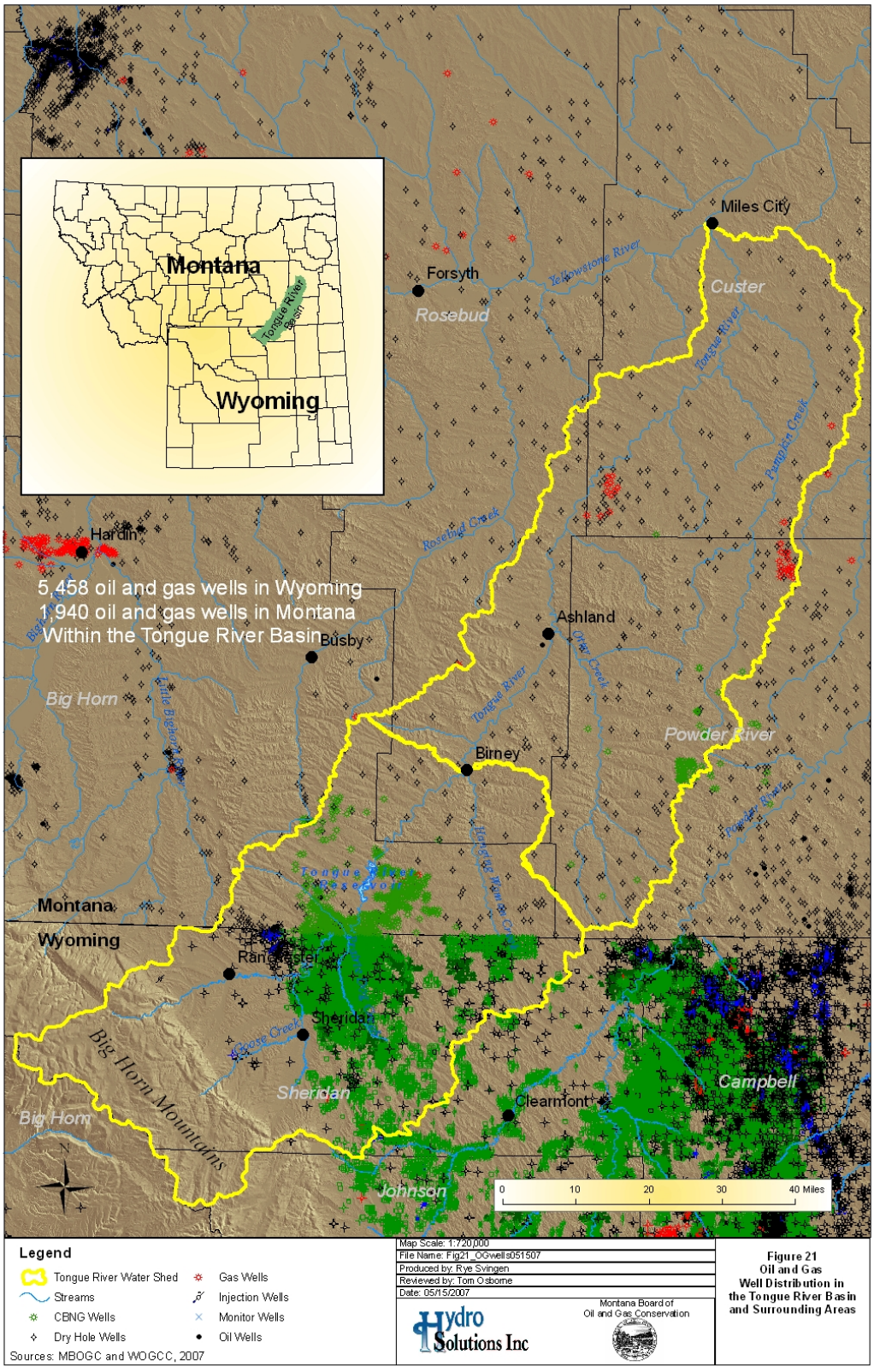

Figure 21 Oil and Gas Well Distribution in the Tongue River Basin and Surrounding Areas

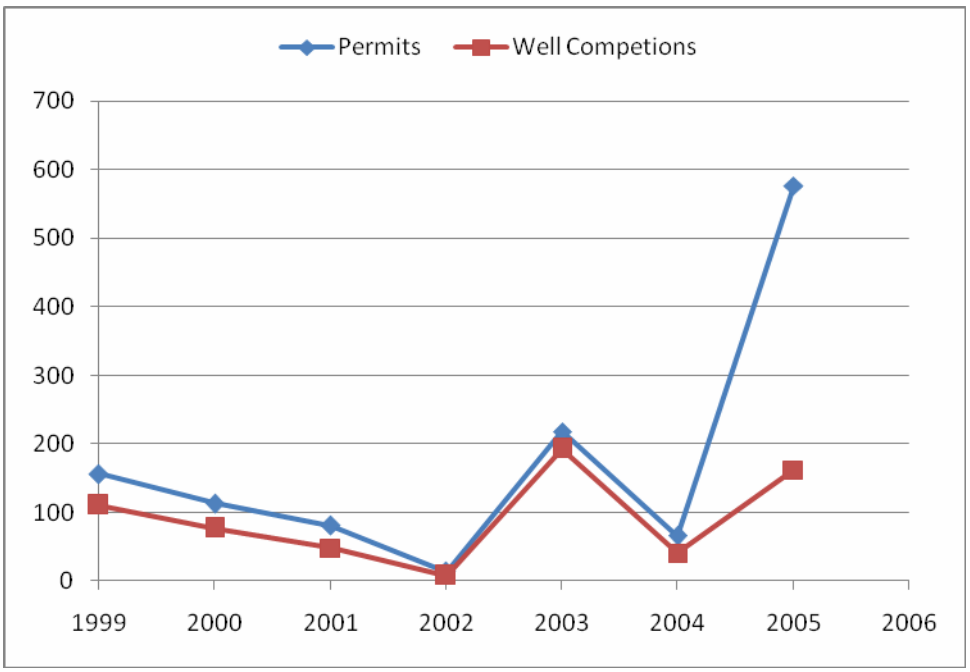

Figure 22 Numbers of CBNG Well Permits and Well Completions in Montana.
Source: Montana Board of Oil and Gas Conservation, 2007).

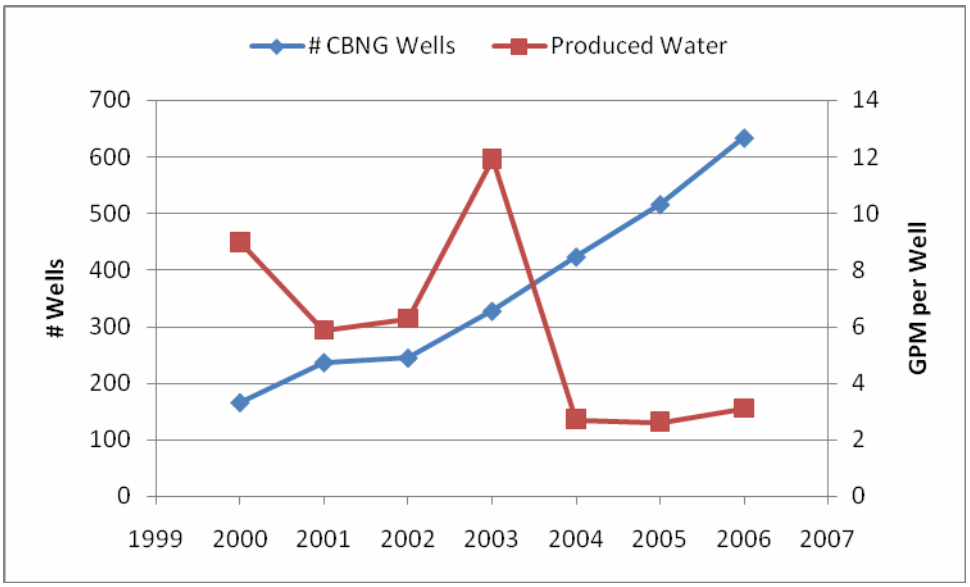

Figure 23 Number of CBNG Wells and Average Rate of Water Production Per Well for the CX Field, Big Horn County, Montana.
Source: (2006 Annual Groundwater Monitoring Report, Fidelity Exploration & Production Co., 2007)

Table 6 Number of Wells and Water Produced from CX Field, Big Horn County Montana.

Year	Well Count	Volume	Volume	Avg Rate	Combined Flow Rate
		Bbls	Ac-ft	gpm/well	cfs
2000	165	18,506,305	2,386	8.96	3.3
2001	236	17,299,446	2,230	5.86	3.1
2002	244	19,119,449	2,465	6.26	3.4
2003	327	48,764,636	6,286	11.92	8.7
2004	423	14,340,143	1,848	2.71	2.6
2005	516	16,876,389	2,175	2.61	3.0
2006	634	24,593,085	3,170	3.10	4.4
Totals		159,499,453	20,560		
Averages	364			5.01	4.1

Source: 2006 Annual Groundwater Monitoring Report, Fidelity Exploration & Production Company.
Key: Bbl= 42 gallon barrel; Ac-ft= acre feet; gpm= gallons per minute; cfs= cubic feet per second.

Initial water production from CBNG wells in the Wyoming portion of the Tongue River basin began in May 1999, with initial gas production beginning in February 2000. The historic trends in numbers of CBNG well permits and well completions are shown in Figure 24. As of early 2007, approximately 2,200 CBNG wells were in production in the Tongue River basin area of Wyoming (WOGCC, 2007). Trends in numbers of producing CBNG wells and average water rate per well is shown in Figure 25. The WOGCC reports that of the 7,398 CBNG well permits issued, 3,974 had expired, indicating that these wells had not been drilled. The historical trends in production of natural gas, water and well counts for CBNG production in the Wyoming portion of theTongue River basin is shown in Table 7. The WOGCC on-line database indicates that 515 CBNG wells in the Tongue River basin were shut-in. This is about one-fourth of the total well count.

The combined history of CBNG well completions in the Tongue River basin is summarized in Figure 26.

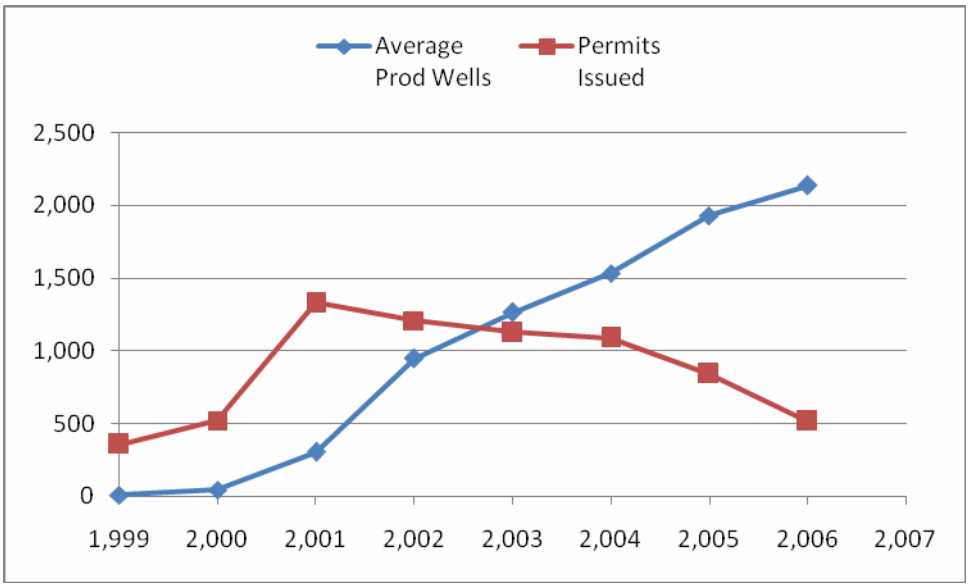

Figure 24 Numbers of CBNG Well Permits Issued and Well Completions in Wyoming (average number of producing wells in each year).
Source: Wyoming Oil and Gas Conservation Commission, 2007).

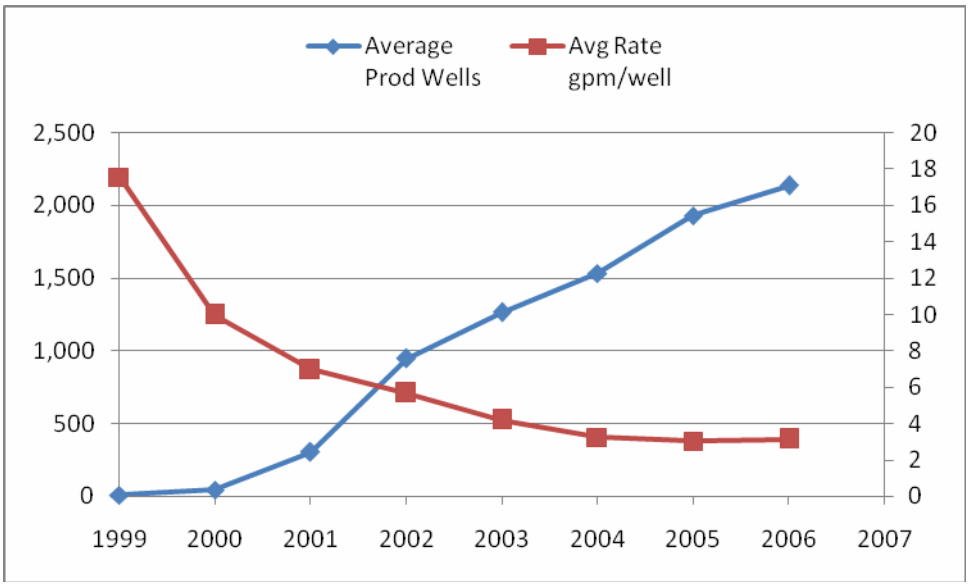

Figure 25 Number of CBNG Wells and Average Rate of Water Production Per Well for the CBNG Wells in Tongue River Basin of Wyoming.
Source: (Wyoming Oil & Gas Conservation Commission, 2007)

Table 7 Number of Wells and Water Produced from Wyoming Portion of the Tongue River Basin.

Year	Well Count	Volume	Volume	Avg Rate	Combined Flow Rate
		Bbls	Ac-ft	gpm/well	cfs
1999	11	2489402	321	17.6	0.4
2000	45	5654563	729	10.0	1.0
2001	305	26590602	3,428	7.0	4.7
2002	950	67312635	8,677	5.7	12.0
2003	1,265	66526676	8,575	4.2	11.8
2004	1,533	62094845	8,004	3.2	11.1
2005	1,928	73063264	9,418	3.0	13.0
2006	2,139	83984547	10,826	3.1	15.0
Totals		387,716,534	49,977		
Averages	1,022			3.8	8.6

Source: Wyoming Oil and Gas Conservation Commission, 2007.
Key: Bbl= 42 gallon barrel; Ac-ft= acre feet; gpm= gallons per minute; cfs= cubic feet per second.

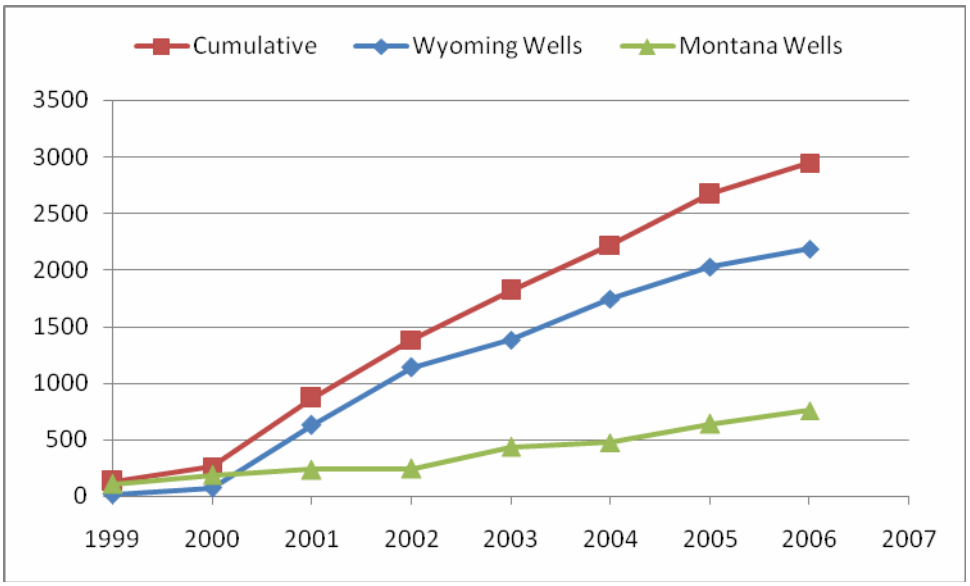

Figure 26 Combined History of CBNG Well Completions in the Tongue River Basin.
Sources: MBOGC, 2006; WOGCC, 2007.

4.0 Discharges to the Tongue River

Growing public awareness and concern for controlling water pollution led to enactment of the Federal Water Pollution Control Act Amendments of 1972. As amended in 1977, this law became commonly known as the Clean Water Act. The Act established the basic structure for regulating discharges of pollutants into the waters of the United States (USEPA, 2007). It gave EPA the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act requires that water quality standards be set for all contaminants in surface waters. The Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. Permits are issued under the "National Pollution Discharge Elimination System" (NPDES). The States of Montana and Wyoming both have been delegated by EPA to administer the Clean Water Act, and do so through their respective Departments of Environmental Quality (DEQ).

NPDES permits are only issued for "point sources" of pollution; that is, those with specific outfalls. According to MDEQ, point source pollution in Montana as of 2006 impairs 10 percent of Montana's streams and 20 percent of its lakes (MDEQ, 2007), with the remainder of impairments due to non-point sources of pollution. The Nonpoint Source Pollution Program is designed to encourage voluntary pollution control activities, provide guidance, and match local funding.

4.1 Point Sources

In Montana, permitting is administered by the MDEQ under the Montana Pollutant Discharge Elimination System (MPDES). Available records indicate that seven MPDES permits exist for direct discharges into the Tongue River, as summarized in Table 8. Permits may have multiple outfalls, or discharge locations. Locations of outfalls from available records are mapped in Figure 27.

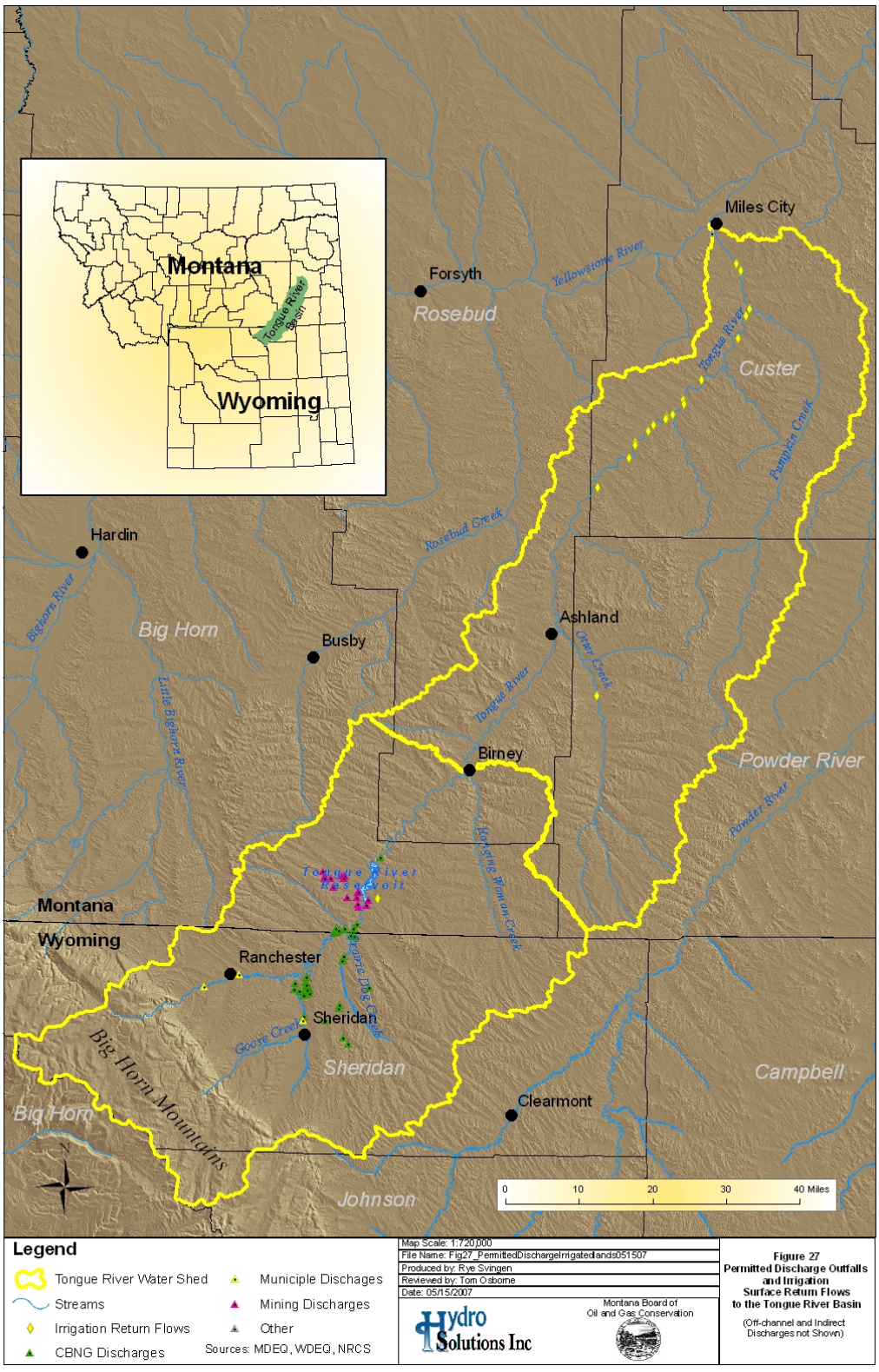

Figure 27 Permitted Discharge Outfalls and Irrigation Surface Return Flows to the Tongue River Basin

Table 8 Summary of MPDES Permits in the Tongue River Basin of Montana.

NPDES#	# of Outfalls	Name	Description	Receiving Water	Type
MT0000892	4	Decker Coal Co. (Decker West)	Surface Coal Mine Effluent	Tongue River Reservoir	Industrial
MT0024210	1	Decker Coal Co. (Decker East)	Surface Coal Mine Effluent	Tongue River Reservoir	Industrial
MT0024619	7	Spring Creek Coal Co. 001	Surface Coal Mine Effluent	Unnamed tributary	Industrial
MTR300198	1	Spring Creek Coal Co	Storm Water - Mining And Oil	Ephemeral Drainages to Tongue River	Storm Water
MT0030457	15	Fidelity Exploration & Production Co	Coal bed methane produced water	Tongue River	Industrial[1]
MT0030724	1	Fidelity Exploration & Production Co	Coal bed methane produced water	Tongue River	Industrial[2]
MT0030660	1	Pinnacle Gas Resources	Coal bed methane produced water	Tongue River	Industrial[2]
MT0028827	1	Montana Dept. of Fish, Wildlife & Parks (Fish Hatchery)	Fish Hatchery Effluent	Tongue River	Municipal

[1] Untreated water discharge
[2] Treated water discharge

Three CBNG MPDES permits were active in 2006. Fidelity's permit MT0030457, originally issued in 1999, was renewed with modifications on April 1, 2006. It allows for the discharge between 1,600 and 2,500 gallons per minute (gpm) of untreated water year round with the rate varying by season. The actual average discharge rate per month under this permit in 2006 was 1,464 gpm for a total volume of 769 million gallons (2360 acre-feet) (J. May, personal communication). Fidelity's permit MT0030724 for treated discharge into the Tongue River also became active April 1, 2006. This permit allows for the discharge of 1,700 gpm year round; however the quality of the water allowed to be discharged varies by season. The actual average discharge rate per month in 2006 under this permit was 602 gpm for a total volume of 186 million gallons (570 acre-feet) and occurred between June and December 2006. The NPDES Discharge Monitoring Report (DRM) for this permit indicated that discharge did not occur for the months of January through May 2006. The treatment system, an ion exchange process known as the Higgins Loop produced by EMIT Technologies, reduces the TDS and sodium content. Pinnacle Gas Resources permit MT0030660 allows for the discharge of up to 1,122 gpm of treated water year round. The actual average discharge rate per month in 2006 under this permit was 236 gpm for a total volume of 124 million gallons (380 acre-feet). Effluent limits associated with the three CBNG permits restrict discharges as to Electrical Conductivity (EC) and Sodium Adsorption Ratio (SAR) based on the

season, with allowable instantaneous EC from 1000 to 1500 µS/cm and SAR from 3 to 5. The more restrictive limits are in force during the spring and summer irrigation seasons. The average discharge rate per month and total quantity of discharge were calculated from NPDES DMRs obtained from the Montana Department of Environmental Quality, Water Protection Bureau, Water Quality Discharge Section. These reports provide average discharge rates in gpm for each month of monitored discharge. The total volume discharged therefore is based on the average discharge per month and does not represent an exact figure.

In Wyoming, permitting is administered by the Wyoming Department of Environmental Quality (WDEQ) under the Wyoming Pollutant Discharge Elimination System (WYPDES). Available records did not allow a categorical breakdown of all WYPDES permits in the Tongue River basin of Wyoming. WDEQ records show there are hundreds of permits; however, many are not active, or are not in use. Some of the principal discharger categories include:

- Three municipal wastewater systems with WYPDES discharge permits; Sheridan, Ranchester, and Dayton.
- Two confined animal feeding operation permits.
- Over one hundred storm water discharge permits.
- One fish hatchery.
- Hundreds of CBNG-related permits.

Of the CBNG permits, many are not active or in use. In addition, the WDEQ issues WYPDES permits for off-channel impoundments used for CBNG produced water storage, although they do not discharge directly to surface waters. As of January 2007, the WDEQ had received application data for 1,106 CBNG impoundments throughout the Powder River basin in Wyoming (Osborne et al, 2007). WDEQ permits to construct were issued for 162 of these impoundments, and compliance monitoring data indicating actual use, were available for 77. Specific WYPDES permit information was obtained from the WDEQ on the four CBNG direct discharges to the Tongue River, as summarized in Table 9.

Table 9 Summary of WYPDES Direct Discharge Permits to the Tongue River in Wyoming.

Permit No.	# of Outfalls	Permit Holder	Facility	Receiving Water	Type
WY0038628	14	Fidelity Exploration & Production Co	Wrench Ranch - Goose Creek	Goose Creek	Industrial[1]
WY0038636	3	Fidelity Exploration & Production Co	Wrench Ranch - Tongue River	Tongue River	Industrial[1]
WY0050571	1	JM Huber Co	POD B Treatment Unit	Prairie Dog Creek	Industrial[2]
WY0054364	1	Pennaco	AC Central Treatment Unit	Prairie Dog Creek via Wildcat Creek	Industrial[2]

Source: L. Krafft, WDEQ, pers. comm.
[1] Untreated water discharge
[2] Treated water discharge

The two Fidelity discharge permits in Wyoming listed in Table 9 are authorized for 0.29 and 0.09 cfs, respectively, but actually have discharged an average of 0.10 and 0.03 cfs, respectively, in 2005 and 2006. The J.M. Huber and Pennaco permits are authorized for 1.33 and 2.27 cfs, respectively, but actually have had zero discharge in 2005 and 2006. The permits on Prairie Dog Creek have a dissolved sodium effluent limit of 50 milligrams per liter (mg/L) and an EC effluent limit of 1000 µS/cm (Bobst, 2007). There are several additional WYPDES permits for discharge of untreated CBNG water to on-channel impoundments in the Tongue River basin. However, these permits do not allow discharge from the impoundments to the receiving streams except under specified storm events which have been shown to dilute any released CBNG water sufficiently to meet Montana's irrigation water quality standards for the Tongue River.

The Decker West and Decker East coal mines have MPDES permits to discharge water derived from pit seepage and storm runoff following treatment in settling ponds (MDEQ, 2006a, 2006b). The average discharge rate from 2001 to 2006 was 1.73 and 1.38 cfs for these mines, respectively. The SC of the discharge averaged 2,522 µS/cm and 2,760 µS/cm, and SAR averaged 5.3 and 13.9, respectively.

4.2 Non-Point Sources

Non-point sources of contaminants are not covered by the NPDES permit system. Potentially significant human and natural causes of non-point sources of contaminants to the Tongue River basin include the following:

- Irrigation return flows: surface and subsurface
- Sediment, bacteria, nutrients and salinity from agricultural sources
- Septic system effluent discharge to groundwater in communication with the river
- Municipal and industrial storm water runoff
- Natural sources including runoff from wild lands and groundwater discharge
- Evaporation from the river and Tongue River Reservoir
- Salinity concentration via transpiration from riparian vegetation

Nonpoint sources have traditionally been addressed by a combination of federal, state and local agencies, including the EPA, USDA Natural Resources Conservation Service (NRCS), DEQs, Montana Department of Natural Resources and Conservation, and county Conservation Districts. In September 2000, the Sheridan County Conservation District (SCCD) in cooperation with the NRCS and the Tongue River Watershed Steering Committee (TRWSC) worked with local landowners to publish a local watershed plan for the Upper Tongue River Watershed (SCCD, 2007). After 5 years, all of the action items in the plan were either completed or otherwise addressed by the TRWSC; however interim monitoring continued to identify unacceptable bacteria levels and excessive sediment in streams. As a result, the TRWSC decided to update the plan and began that process in July 2005. A revised version of the watershed plan was completed in March 2007 (SCCD, 2007).

Nonpoint source control efforts in the Wyoming portion of the basin undertaken by the SCCD (SCCD, 2005) include:

- Completion of three animal feeding operation improvement projects and three projects in progress;
- Three streambank/riparian improvement projects with one under construction;
- Two septic system projects with three in progress;
- Educational programs on animal feeding operation;
- Pathogen workshops;
- Development and maintenance of a progress register map;
- A series of educational brochures published and distributed to 1300 residents in the Upper Tongue River Watershed; and
- A video describing a septic system replacement and design considerations.

Other nonpoint source improvement projects were reported for the Goose Creek watershed (SCCD, 2005). The SCCD report acknowledged that the

voluntary nature of the program makes it difficult to determine specifically what types of improvement projects and/or assistance will be requested by landowners.

In Montana, Conservation Districts in Big Horn, Rosebud and Custer Counties undertake educational efforts and sponsor grants to support voluntary reductions of nonpoint source contaminants. In 2004, the Rosebud County Conservation District formally adopted Land Use Ordinance #1 which is intended to regulate management of CBNG produced water and to require additional bonding of CBNG water management facilities (Rosebud CD, 2007).

In its Tongue River TMDL Status Report (MDEQ, 2003), the MDEQ acknowledged that it is difficult to determine the effects of all agricultural sources on the Tongue River because of the large watershed size and multiple contributions from different sources. Agricultural land and rangelands comprise approximately 72% of the Tongue River basin (NRCS, 2002). Since irrigation is the largest water use in the Tongue River basin, irrigation return flows are a potential source of contaminants, however little data are available (MDEQ, 2003). The NRCS Phase 1 Rapid Aerial Assessment identified 20 visible irrigation return flows (Figure 27) along the Tongue River in Montana, exclusive of Rosebud County. Most irrigation return flows occur via the subsurface as part of groundwater discharge to streams. No comprehensive inventory or estimate of surface or subsurface irrigation return flows is known to exist in either Montana or Wyoming.

The portion of the Tongue River immediately downstream from the TY diversion dam to the mouth is listed as impaired on the MDEQ's current (2004) 303(d) list, and on the Draft 2006 list. The probable cause of impairment is identified as “Low Flow Alteration”, and the identified probable source are “Dam Construction” and “Flow Regulation/Modification”. Much of the water in the Tongue is diverted for irrigation at the diversion during low flows (Bobst, 2007). Water diverted at the TY diversion dam is consumed through crop evapotranspiration, or may reach the Tongue River or Yellowstone River as irrigation return flow. During low flow periods, irrigation return flows along with inflows from groundwater and Pumpkin Creek potentially have a large effect on the quality of the Tongue River between the T&Y diversion and Miles City. In a review of Tongue River surface water data for Water Year 2006, Bobst (2007) attributed elevated mean monthly EC and SAR values at the Miles City USGS station primarily to the combination of diversion of relatively good quality Tongue River water at the T&Y diversion dam and probably inflows of water with poorer quality from irrigation return flows, groundwater and tributaries.

Evaporation from the Tongue River, and particularly the Tongue River Reservoir, also reduces the volume of water and increases the salinity of the water released. A USGS study by Cannon and Johnson (2004) established the surface area of the reservoir at nominal capacity at 3,497 acres. The gross average annual evaporation rate is 40 inches, with 16 inches average annual precipitation, giving net evaporation of 24 inches. The evaporative loss from the

Tongue River Reservoir is equivalent to an average of 9.7 cfs on an annual basis. This is about 2.2% of the median discharge of the Tongue River at the State Line gauging station (443 cfs). Since water evaporates leaving the salts, the salinity theoretically increases by an equivalent percent, or about 14 µS/cm, based on a median SC of 634 µS/cm (median of 35 laboratory measurements in 2004-2005). USGS water quality data show an increase in the median SC of 31 µS/cm between the State Line and Tongue River Dam stations for 35 paired measurements in 2004 and 2005.

Natural processes can increase or decrease salinity, sodium and other contaminants, but the water quality effect of these processes in the Tongue River basin is not well understood. Transpiration of groundwater by riparian vegetation along the Powder River, for example, has been shown through USGS studies to cause an average decrease in flow of approximately 0.3 cfs per river mile from Arvada, Wyoming to Locate, Montana (Lenfest, 1987; Ringen and Daddow, 1990). Such withdrawals from the river remove water, leaving the salts and increasing the salinity of the surface water-groundwater system.

In summary, there are a total of 7 CBNG point source discharge permits with 36 outfalls to the Tongue River in Montana and Wyoming. There are three mine discharge permits in Montana with a total of 13 outfalls. Some discharges are for untreated water and some are for treated water. Not all permits or outfalls have been in recent use. In addition, there are hundreds of discharge permits in Wyoming for CBNG impoundments, municipal, commercial and private facilities, most of which do not discharge directly to the Tongue River. Non-point source discharges to the Tongue River from urban sources in the Sheridan area and agricultural sources in both states may be significant but are not currently understood. Natural processes occurring in the basin are known to affect water quality, but are not well understood or quantified.

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